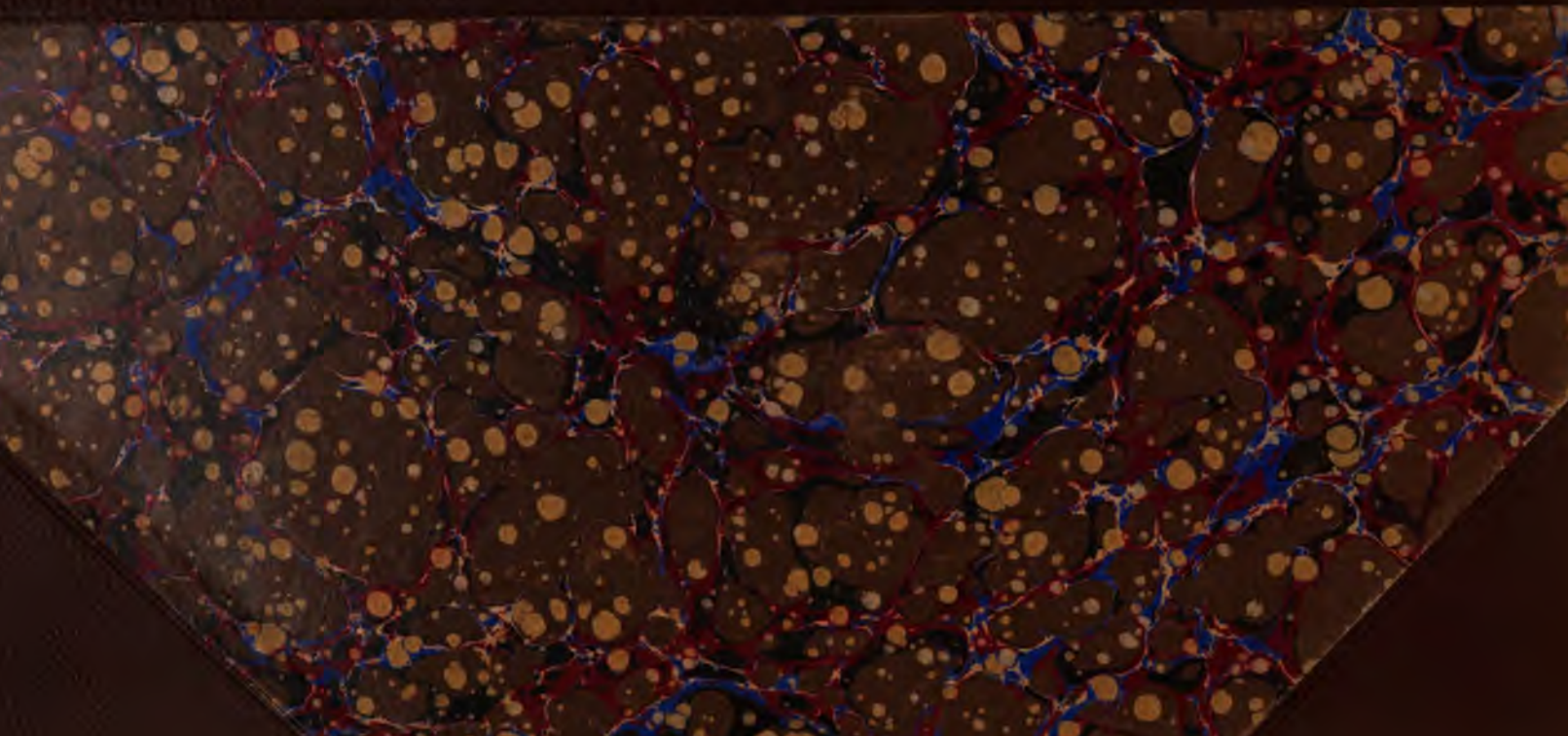


TRANSACTIONS

OF THE

SEISMOLOGICAL SOCIETY

OF JAPAN.

VOL. V.

1882 *MAY—DECEMBER.*

TOKIO,

GOVERNMENT PRINTING OFFICE,

1883.

(Reprinted by the Nisshusha Printing Office.)

CONTENTS.

PAGE

DR. E. NAUMANN,—*Notes on Secular Changes of Magnetic Declination in Japan*,..... 1

Don E. ABELLA Y CASARIEGO,—*Monografia Geológica del Volcan de Albay ó El Máyon*,..... 19

DON J. CENTENO Y GARCIA,—*Abstract of a Memoir on the Earthquakes in the Island of Luzon in* 1880,..... 43

PROF. J. A. EWING,—*Seismological Notes:—I, A Duplex Pendulum Seismometer. II, The Suspension of a Horizontal Pendulum. III, A Speed Governor for Seismograph Clocks*..... 89

T. DAN, S. B.,—*Notes on the Earthquake at* Atami, *in the Province of* Idzu, *on September* 29, 1882,..... 95

Constitution, Committee Rules, Officers, and List of Members of the SEISMOLOGICAL SOCIETY OF JAPAN,..... 105

NOTES ON SECULAR CHANGES OF MAGNETIC DECLINATION IN JAPAN.

BY

DR. EDMUND NAUMANN.

[READ MAY 2ND, 1882.]

It is a well known fact that those phenomena which indicate the magnetic force of the earth are subject to changes which show as a rule a certain regularity by their dependence on periods of time. The magnetic declination varies with the seasons and even every hour at one and the same place; there is also a continual secular change. The hourly oscillations of the magnetic needle are mostly regular, i. e. periodical, and these periods are known to be dependent upon the position of the sun. At night-time the needle is almost stationary, but with sunrise it commences to move, and then continues this motion until about noon, after which it again moves gradually back to the original position. Irregular (non-periodical) movements of the needle may have something to do with earthquakes and volcanic eruptions. Of the secular changes of declination the most complete series of observations has been made at Paris. Here the declination amounted to 8°10′ E. in 1550, then increased to 11°30′, which value was reached in 1580; after this a decrease took place, it became 0° in 1663-1666, turned West and gradually increased in this direction up to the year 1814. At this time it had obtained the value of 22°34′, and now commenced to move back in an easterly direction, but with considerable irregularity. It is, as far as I know completely unknown to what causes these secular oscillations of the needle can be attributed, mainly because the material at our disposal does not extend over a sufficient length of time to form any valuable judgement upon these difficult questions.

Therefore I do not hesitate to bring the scanty results of some investigations on the subject before this society, though I must apologize for offering my observations in a very incomplete and rough state. This may perhaps be a good occasion to call the attention and the interest of this society to a subject which must be no doubt of highest importance for seismic science, and I hope that some one who is more conversant with the subject than I may soon show whether there is, or is not, an intimate connection between magnetism and vulcanism, and where this connection exists.

Unfortunately the number of magnetic observations in Japan is very limited indeed. It is true that the coast of Japan is pretty well surveyed, and the magnetic variations so important for the mariner are given on published charts, but by a comparative investigation of these data it can be seen that many of the observations appear to be inaccurately determined, if their applicability to scientific purposes is considered, and, on the other hand, these observations are scattered over a large number of years. They are however the only source by which we can construct the present magnetic meridians of Japan. I have tried to make out on the map the courses of the 4° W. and 5° W. meridians. Rough as the curves determined in this way may appear, it can be seen that they follow a crooked line, and that their course appears to conform to certain lines peculiar to the configuration of the Japanese Islands. Materials for constructing even approximately the isoclines and the isodynomical lines are completely wanting, as the magnetometer measurements that have been made only relate to a very small part of Japan. These more scientific determinations were undertaken during the two last years for the geological survey and their results have been published in the *Mittheilungen der Ostasiatischen Gesellschaft.*

In order to compile in the shortest time possible a general topographical and geological map of Japan, and for the purpose of getting the means to provide the surveyors later on with instructions relating to local specialties, I had decided from the very beginning of the geological survey to carry out myself a reconnaissance of the whole country. This

work I commenced in the beginning of last year, being helped by a few assistants. During 4 months time almost uninterrupted flying surveys had to be made (besides 1 month devoted to the geological Survey of Ani), the total length of the route surveyed by myself being about 400 *ri*. Extensive observations were made both on the geology and on the topography of the country, which entailed an elaborate use of the magnetic compass. Joining the material collected on these excursions together with that represented by the *Chissoku Zenkoku Chiudzu*, made in 1800-1819, and known as Ino's map of Japan, I am enabled to compile a map which will at least correctly show the general features of the country. Mr. Knipping has published in the *Mittheilungen der O. G.* very favorable remarks as to the accuracy of Ino's map, and I took occasion to convince myself that the *Chissoku Zenkoku Chiudzu* is sufficiently correct to be used as a basis for the reconnaissance map of the Geological Survey.

Ino's map contains a great number of compass measurements. These are given in Japanese characters, and the total sum of all the angles laid down in the map in this way amounts to not less than 2040. Comparing the magnetic azimuths as given by Ino with compass measurements of exactly corresponding directions as determind by the Reconnaissance, it can be shown, as I shall endeavour to prove, how much the magnetic declination has changed since Ino. Ino's field books have unfortunately been lost by the burning down of the Uyeno temples in 1868; different essays written by him are likewise no longer in existence, and the map edited in 3 different scales and some record books accompanying this map are all that have been preserved. This map gives a means for the determination of the course of the isogones for the beginning of this century. Possibly the completion of a map, showing the system of the isogones for Ino's time and the accurately determined system of the present isogones, isoclines and isodynamical lines, may in future lead to a better understanding of the causes of the secular oscillations of the needle. I need scarcely point out that continued studies in this direction promise the more, as Japan mainly extends in a North and South direction, and is therefore

especially fit for magnetic studies; and further, because we have to do with a country which, as history tells us, had periodically a very high volcanic activity; besides Japan might deserve the special and prominent attention of those who are interested in magnetic studies, as it is part of a magnetic island on which the declination is West. The dependence of many of the magnetic phenomena on electric currents moving round the earth may be considered as probable. In consequence we may perhaps expect the existence of a connection between magnetic phenomena and certain internal conditions of the earth, as the earth itself will have its electric currents, and these currents ought to be influenced by internal changes.

In 1870 the *Daigaku* wisely undertook to publish Ino's maps together with his record books, which latter also contain some prefaces and introductions, partly by Ino himself, partly by his colleagues.

Mr. Sekino has, according to my advice, translated the text accompanying the maps, and from his translation I quote the following words of Takahashi Sakuzaemon: "Now the maps have been completed and in place of Ino Tadayoshi, who died before the maps could be published, I myself state the following: The Europeans say that the compass needle generally declines to the West, not pointing due North, and that this variation increases or decreases. Ino Tadayoshi had no better instruments then the common magnetic compass. In Europe these instruments are made with great perfection. Ino, however, did not use any foreign made compass, he on the contrary prepared himself compasses of different kinds. He discovered that the bearings taken with his own compass were always the same, and saw the needle point due North quite constantly, so that anything like the variation of the compass needle was never noticed. From these results he determined that by careful and proper workmanship instruments of the greatest delicacy can be made, and that any piece of iron has much influence upon the needle, deviating it more or less from pointing true North and South. If any one would re-observe the bearings of any places on the map with the common kind of compass, it would most probably give some difference."

Ino obviously overlooked the magnetic declination, because at his time the meridian of no declination passed through Japan. He was therefore right to a certain degree, except of course in his opinion of the greater perfection of his own instrument. Still one might be astonished that he who was so well versed in determining the latitudes with almost absolute accuracy, neglected those larger declinations which at his time appear to have existed in several parts of the country. The reason of his neglecting the smaller declinations is very easily understood. His compass was, as it appears, too roughly divided, and did not show more than 240 divisions, so that the smallest division of his compass would correspond to $1\frac{1}{2}°$ of the proper division. Besides this, Ino's compass must have possessed a certain error due to the non-congruence of proper and magnetic axes of the needle. It will not be possible to determine the amount of this error, without getting the compass itself. Repeated inquiries about this compass of Ino gave again and again a negative result; still I consider it possible that it has been preserved, and take the liberty of inviting the members of this society to assist in its discovery. The just described error of the compass is a constant one, and cannot therefore influence the general results derived from a comparison between Ino's bearings and the present bearings. Besides the said error, there is still another one, caused by friction. Ino's readings may be considered to have an accuracy of about one degree. This is by no means inconsiderable if Ino's bearings are to be used for the determination of the isogones at his time. But it must be borne in mind that the value of the whole investigation cannot be destroyed by this objection, as this unfavorable circumstance is counterbalanced by a favorable one, namely, by the *great number* of the bearings given in Ino's map. In the Northern part alone, in which I travelled last year, and only for this part did I try to determine the change of magnetic declination, there are not less than about 80. Moreover, a profound study and a careful examination of the map leads to data which do not depend on the bearings given, but on bearings measured in the map, and therefore by carrying the work to the greatest possible extent

one ought to arrive at a point not very far from the truth.

The methods applied to determine the magnetic variation at Ino's time are as follows.

1. Such bearings of Ino as are given in numbers on his map are compared with bearings measured during the reconnaissance (prismatic compass). The difference between both is determined; the present magnetic variation was taken from charts or approximately ascertained, and subtracted from this difference. + signs have the meaning declinations E.,— signs indicate a declination W. This method is illustrated by the accompanying diagram, Fig. 1, of which the following is the explanation.

NS, Astronomical meridian.
P, Mountain sighted.
M, present position of needle.
M_1, position of needle at Ino's time when declination W.
M_2, position of needle at Ino's time when declination E.
Declination at Ino's time $= \alpha - \beta - \varepsilon$ (West) or
$= \alpha - \delta - \varepsilon$ (East).

2. Sightings taken during the reconnaissance have been compared with the directions of the corresponding lines of Ino as determined by measurement on his map.

This method can be applied only in such cases where the station is determined by Ino and the sighting taken not far away from one of Ino's sightings which bears to the same point. From this the declination was determined as before.

3. Some of the more prominent peaks in Ino's map (Taihezan and Ganjusan) are not in the proper position on account of Ino's overlooking the declination of the compass. The proper position of these peaks was determined in Ino's map, and the difference of Ino's given direction from the direction to the newly determined point measured. The value obtained corresponds approximately to the magnetic declination at Ino's time, as illustrated in Fig. 2, explained as follows:—

I, Direction given by Ino.
P, new position of peak.
β, angle given by Ino (small correction applied).

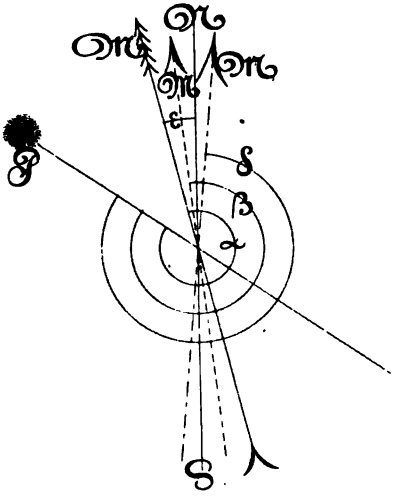


Fig. 1.

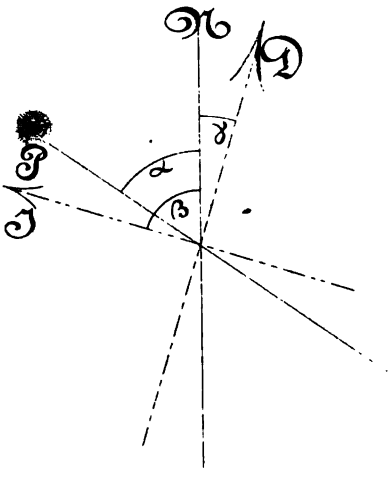


Fig. 2.

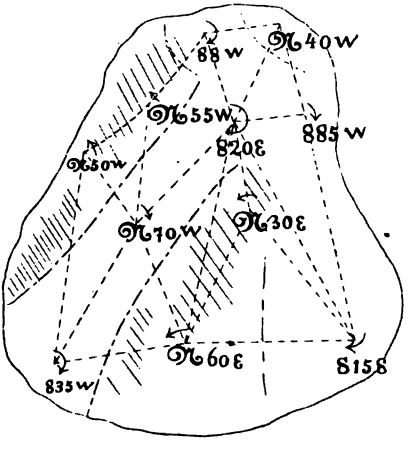
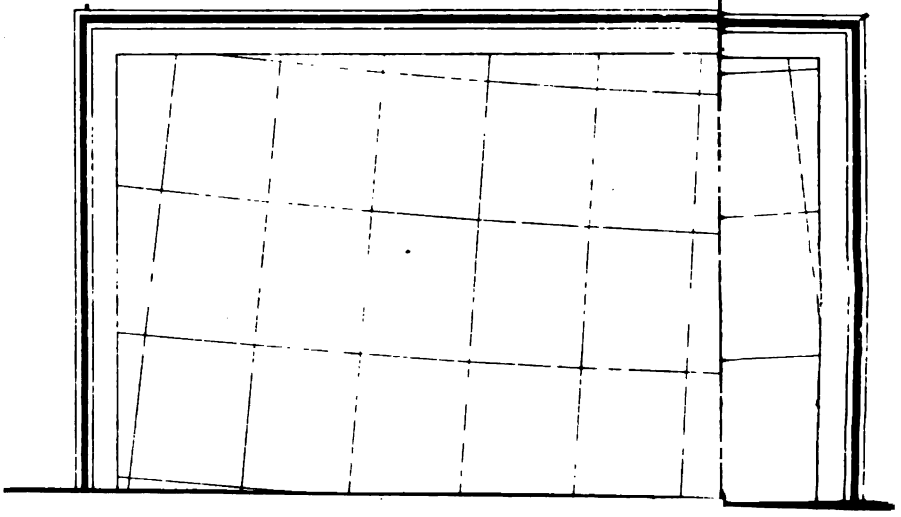


Fig. 3.



α, angle measured from map, between newly determined direction and true meridian (true azimuth of direction to peak P, determined approximately by mapping).

D, Direction of magnetic meridian at Ino's time.

$\gamma = \beta - \alpha$ = approximate declination at Ino's time.

5. All those field sketches forming a connection between two stations contained in Ino's map were put together, the straight distance of the stations and the magnetic azimuth of the connecting line were measured, and the results obtained compared with the corresponding lengths and angles in Ino's map. Though the differences of direction procured in this way can not be used for ascertaining the former magnetic variation at the single localities, it is worth notice that the average of the deviation from Ino's directions very nearly corresponds to the probable average increase of the declination since Ino, as derived by application of the methods mentioned before.

Before commencing a discussion of the tables, and of the curves shown on the accompanying map of Japan, I have to remark that the error of the prismatic compass which I made use of, has not yet been determined sufficiently, and that the graphic exhibition of my results can only be taken as a rough sketch.

Most likely it was first at Tokio that Ino was led to the conviction of the great exactitude of his compass on account of its constantly pointing to the true North. For this reason it must be of special interest to measure those directions to distant mountains, which he determined from Tokio. His map contains a great number of red lines diverging from a point at Fukagawa. Mr. Shiraishi selected a point at Fukagawa which must have been very near to Ino's station, if not coinciding with it, and determined the present magnetic azimuths of a number of these directions. All could not be taken, as the weather has been very unfavourable during the last months. The average value of the former declination obtained from these observations is 1° 2′ W. One might have expected a number smaller than this; possibly the just mentioned value will be reduced by subtracting the error of the prismatic compass used. Properly the single values indicating the change of the magnetic

variation ought to be the same, but every difference obtained from any direction differs from the others. The extreme values are even not less than 2° from each other. This appears to prove that Ino's readings were indeed somewhat roughly taken.

I am able to state however with absolute certainly that the meridian of no declination must have passed through the country at Ino's time. Those old bearings which I tested were taken by Ino during the years 1800 and 1801. Berghaus's *Physikalischer Atlas* contains a map of Erman showing the isogones for the years 1827—1831. Here the 1° W. meridian can be seen to pass through the Eastern part of Yesso, and to cut off some peninsulas on the Eastern coast of the main island. This gives roughly an average increase of 5° from 1800 to 1881, and of 3° from 1830—1880. According to the values given in charts of one and the same harbor, but relating to different years, we obtain for middle and Northern Japan,

Nanao, 1870—1879 magn. decl. increased from 4° 35′—5° 10′, 35′ in 9 years, or 4′ annually.

Miyadzu, 1867—1879 magn. decl. increased from 4° 30′—5° 15′, 45′ in 12 years, or 3.8′ „

Awomori, 1870—1874 magn. decl. increased from 4°—5° 20′, 1° 20′ in 4 years, or 20′ „

The first two of the values determined very nearly agree with the average annual increase according to Ino's and Erman's observations. On some of the charts the magnetic variation is said to increase about 1′ annually; but this is certainly too little.

While in Northern Japan the magnetic declination certainly increases, it seems according to some charts that it decreases in the South.

If the values for the declinations at Ino's time are put down in a map of Japan and the curves are constructed, the meridian of no declination is seen to pass in a very irregular way through Northern Japan, its longest axis being contained in a median zone of the Island. The West and East declinations are divided left and right of this zero meridian, a result which proves the reliability of the whole process. Strange to say we obtain a very large East declination for Morioka, or the neighbourhood of Ganjusan, and other observations taken in this

region point out that there was at Ino's time a kind of magnetic island in Northern Japan, with some place near Ganjusan as a centre. A Westerly increase of declination since Ino, amounting to about 19°, is so abnormal that one might rightly expect misreadings or something of that sort to have been committed either by Ino or by myself. But repeatedly examining Ino's plottings I always find

1st, that Ino gives N. 60° W. as the bearing of Ganjusan taken from Uyeda near Morioka.

2nd, that this given bearing agrees with the angle measured in the map.

3rd, that however Ino's position of Ganjusan is certainly wrong, as the mountain is more to the right if seen from Morioka.

4th, that the considerable deviation of Ino's bearing at Uyeda is not the only exception, but that the direction given by Ino for the line Sanbonyanagi Ganjusan (N. 45° W.), does not differ from the corresponding direction measured on the map, but from the newly determined point for Ganjusan (N. 33° 50′ W.) about 11° 10′.

Besides, the declinations for Tokudamura and Minamihidzume (still more South), the former having 6° 50′, the latter 4° 45′, and lastly Ishiboriza, showing an East decl. of 4°, are all abnormal. These larger East declinations follow each other very regularly, becoming the larger the nearer they come to the place of largest Eastern declination. I can not consider it possible that all these large deviations should be accidental, and I am myself nearly convinced that there has been at Ino's time an irregularity in the isogonic system in the immediate neighbourhood of Ganjusan. Whether this irregularity had any connection with the volcanic seat of the just mentioned volcano, I am of course perfectly unable to say; but certainly the close neighborhood of an abnormal magnetic centre and what may be called an active volcano deserves our attention. According to my knowledge there was no volcanic eruption nor any big earthquake in the regions near Ganjusan at the time of Ino, though a very big subterranean noise was noticed in 1823, which is said to have come either from Ganjusan or from

another mountain near it.

One might not believe that Ino could overlook deviations of the compass needle amounting to not less than 14° 30°, but it must be borne in mind how persistently Ino held to his idea of the great superiority of his compass. On the other hand, Ino's work had to be carried through against so many difficulties as to make even that error excusable. He states himself that the survey from Noheji to Sendai offered special difficulties on account of the weather having been unceasingly rough and snowy.

To be free from reproach I shall not conceal a few results which do not confirm the just described magnetic irregularity. The difference of Ino's direction Morioka-Hannamaki and that determined by a survey of Mr. Fujitani gives 4° 45′ W. for Ino's time. Further, the examination of Ino's bearings to Hayachinesan from a few stations on the Oshiukaido, under application of method 3, gives 3 west declinations of 2° 15, 2° 30 and 1° 40′. Since not much weight can be given to the angles found by a flying survey, simply because the amount of error depends upon too many varying circumstances, the 3 last values are likewise of inferior importance. The position of Hayachine in Ino's map namely was determined by very acute angles, so that it came by far too much East.

As stated before, the old declination of Tokio was determind to be 1° 2′. The meridian of 1° therefore took its way probably straight across the island approximately in the direction of the astronomical meridian, setting aside the smaller curvatures. Such magnetic curves would have shown quite a different shape at Ino's time from the present.

Before concluding this paper I may be allowed to add an interesting observation which I was fortunate enough to make on the top of Moriyoshisan, an old volcano near the Ani coppermines, Akitaken. East of the highest point of this mountain lies a small flat covered with dwarf pines and large blocks of lava. At the eastern border of this place I found a block consisting of *exactly the same material* as the surrounding ones, showing very strong magnetism. The block, consisting of granular *Augitetrachyte*, measured about 1.90 met—1.50. By

none of the blocks in the neighbourhood could any effect upon the needle be observed, while the one in question made it revolve very decidely, so that the needle described an arc of 155° in some cases. Standing upright on the block, I could not observe more than a very slight deviation; but lowering the compass, the needle was seen to move very decidedly. The degree of deviation was found to be very different at different points.

The accompanying sketch, Fig. 3, shows the distribution of magnetism. The angles given in the sketch are the bearings taken from the single points to a certain mire whose proper bearing was found to be N. 68 W.

The sketch shows the amount of deviation at different points of the surface and in what direction the needle was turned. The East deviations are divided into two zones which cross each other; on the islands cut out by these zones the deviation is to the W. Fragments broken off had a very distinct polar magnetism. It may be that the magnetism of the block was caused by lightning.

In taking observations with the compass, errors may be experienced by the influence of magnetic masses or blocks. But these accidental sources of magnetism may be easily discovered with even little attention. On the top of volcanic mountains it is always necessary to take the sightings from a number of points. I mention that Mr. Knipping observed a very considerable deviation on the top of Nantaisan. Comparing my bearings taken from the top of Chokai at different points, I found that they differed very considerably.

The above notes do not pretend to be anything more than a kind of programme or introduction for an investigation which will extend over a great number of years. The magnetometer observations of the geological survey will successively be carried out through the whole country, and in the course of the said survey all the bearings laid down in Ino's map will be practically tested in the field. This will lead to the construction of magnetic maps both for the present time and for the beginning of this century.

DISCUSSION.

Mr. Knipping said:

With regard to the curves of equal magnetic variation, for the present and for Ino's time (1802-1819) as charted and explained by Dr. Naumann, I am of the opinion, that the observations do not justify some of these curves, at least not throughout their entire length.

The 5° W. curve for the present time follows almost the coastline of Aomori bay in its various bends and different directions; at Niigata it trends out to sea, making a large angle with the previous direction; it encloses Sado island and then returns far into the interior of the main island, forming at Sado an acute angle; from the interior it runs out to sea again off Etchu.

The 4° W. curve of the present time follows the coast line of the Kii peninsula at sea in a S.S.W. direction, turns round Oshima, parallel to the coast line, runs up the Kii Channel, about N. W., and turns off Awaji to the S. and S. W. again, all within a radius of about 60 to 80 nautical miles.

On no variation chart, based on a sufficient number of observations, have I ever noticed similar irregularities. If account was taken of the probable error in the observations, and of the fact, that in nautical charts, which Dr. Naumann has consulted, the variation is often given at sea in places where no actual observations were taken, solely for the convenience of the mariner in using the chart, and that in many cases the data are approximate only to 20′ or 30′, all these irregularities would disappear.

The line of no variation for Ino's time resembles in the interior, latitude about 37-38° N., an S flattened down considerably in its lower portion; but this extraordinary shape, which one will look for in vain in a reliable variation chart, similarly disappears, if a probable error of 0.5° to 0.7° is allowed for.

In general, curves can only be accepted as fairly representing what they are intended for, when many observations are at our disposal, not only *on* the curves, but also *between* them.

Whether curves are fair or not, can be further easily tested thus: if two persons, independently, draw by means of the same data the same or nearly the same curves, then the latter may be taken as fairly representing the observations, but in the present instance it is evident, that this test would give unsatisfactory results.

The discovery of Dr. Naumann, that near Morioka in Northern Nippon the variation at Ino's time amounted to 14° E. and decreased gradually to 0° towards the N., W. and S., within a radius of 80 or 100 nautical miles from this point, is highly interesting and important. *A similarly quick change of the magnetic variation, distributed over such an area as the one shown on the chart, is until now only known near the magnetic poles.* It is thus to be hoped, that Dr. Naumann will publish in full all the observations on which his curves of equal variation for Ino's time are based, so as to leave no doubt about the correctness of his results, and also the variation, as found by himself at places near Morioka, because it is highly improbable that a local magnetic disturbance of such magnitude and extent, as stated for these regions and Ino's time, should have entirely disappeared in 70 or 80 years.

Dr. Naumann replied :—

If Mr. Knipping would take the trouble of re-examining my paper, he would find again and again remarks which point out how little value is attributed by myself to the smaller sinuations of the isogonic lines represented in the map. This map, which I introduced as a "rough sketch" only, is intended to be a mere illustration to my notes. Notwithstanding, Mr. Knipping is attacking in the first line the details of the "sketch"; he even describes the course of the curves very exhaustively and in this way makes up for a deficiency of my paper. I myself have failed to give anything more about the present curves then a short remark about their crooked character, and the "apparent" conformity to the configuration of the Japanese Islands.

Regarding the Sado sinuation of the 5° W. curve, described at length in the foregoing part of the discussion, Mr. Knipping is not aware of the more accurate determinations forming the

basis of this part. Just for the construction of the said sinuation I was able to make use of about 10 declination values, partly determined by magnetometer measurements, partly established by surveyors of the triangulation of Japan. Those declinations given far out at sea, whose localities could not be fixed approximately, were entirely neglected. I mainly used the special plans and charts of the harbors and bays. For the Idzu curve a greater number of chart declinations and also some magnetometer declinations were employed. That the Sado sinuation was founded on something else than on mariners' observations alone, could be decided without a knowledge of the notes to which the sketch belongs, as the said sinuation goes very far inland. It can be seen from these remarks that Mr. Knipping's assertion: "*all these irregularities* would disappear if account was taken, etc." is *entirely without foundation*. It may be that the special character of many sinuations is incorrect, that this special character will experience substantial changes at a time when a greater number of accurate observations shall be at our disposal, some of the sinuations may even disappear, but certainly not all will vanish.

As far as the irregularities of magnetic lines are concerned, generally these can of course only be shown on maps drawn on a very large scale. Such detailed magnetic maps are still very rare, and consequently very little is known about these irregularities. Magnetic maps on a very small scale, showing for instance the whole surface of the earth do not allow the representation of the special irregularities. Such general maps are a kind of illustration to the theory of Gauss, according to which the magnetic phenomena observed on the surface of the globe are functions of Latitude and Longitude.

The causes of the smaller irregularities consist in conditions of the superficial parts of the earth. The shape of the surface may have some influence, and we may perhaps expect greater complications in the details of magnetic curves where the differences of level are so considerable as on and near Japan.

Lamont's magnetic maps of Bavaria and Southern Germany show the declination lines in intervals from 10′ to 10′.

Some irregularities may be noticed on these maps. The distance of two declination curves is on an average about 4 German miles; West of Karlsruhe, however, the 1° 40′ and the 2° curve are only 1 mile from each other and near Darmstadt the distance amounts to 8 miles. A similar irregularity may be noticed between Bamberg and Bayreuth, and a still more considerable one in the neighbourhood of Salzburg.

The Bay of Finland gives a further example of exceptional directions of the needle. The irregular distribution of magnetism in this part has been investigated by R. Lenz. He found the irregularity to be greatest on the Island of Stenland. At Junnersö he found not less than 9 poles. It is highly probable that this peculiar irregularity may be caused by masses of iron ore found here at a number of points. These examples prove the existence of irregularities in other parts of the world.

I do not attribute much value to the details of the curves for Ino's time and I have said so in my paper, but I cannot agree with Mr. Knipping if he maintains an error of 0.5 to 0.7° would be sufficient to change the irregular zero curve into a regular one. This change would require a very peculiar and very improbable distribution of the errors. An inspection of the original map will convince Mr. Knipping that the greater number of the data by which the curves were determined are *of course* not on but between the curves. In constructing the map I have endeavoured to draw the curves in exact accordance with the material, however insufficient it may be, I had at my disposal. If two persons (to use Mr. Knipping's example, but not to the same effect), working according to this principle of mine, draw curves, quite independently from each other, but employing the same data, their representations will become nearly the same; but if they do not work according to the same principle, if f. i. one rejects all those observations which make the curves irregular, then one will get a more complicated, the other a less complicated system.

For the construction of the curves relating to Ino's time I made use of about 50 compass measurements. These were taken during the last year on my travels through Northern

Japan. It must be remarked that my notes apply only to North Japan and that the curves for the present time were put in for comparison.

With regard to Mr. Knipping's final remarks I may be allowed to repeat what I stated in my paper, namely, that my notes are only intented to be an introduction to future studies and investigations, and that I long for the time when it will be possible to publish the magnetic materials to be collected by the geological Survey in a far more complete and definite state than those scanty notes which I took the liberty to bring before this society.

Mr. Knipping replied:—

If Dr. Naumann himself also places little value on the sinuosities of his lines of equal variation, then there was all the more reason to suppress them as much as possible in a *rough sketch*, as those mentioned by me are improbable on the face of them; and a sinuosity, amounting to an acute angle in one line, disappearing entirely in the next one, distant from the first about 100 miles and on the whole parallel to it, can certainly not be called a *small* one, it is rather an *unusually large* one.

That the line near Sado was drawn with the help of values partly determined on shore, of which I am well aware, does not prove anything in favor of this angle, as long as the probable error is not at least roughly given.

The examples adduced from the magnetic survey of Bavaria and Southern Germany, as well as the one in the bay of Finnland, cannot be compared with the irregularities mentioned by me, because they are different in kind. In the first case *varying distances* in a system of isogones, running about *parallel* to each other, have nothing in common with our case, where *the angles or bends* in *one* line, do dot appear at all in the *next* one. Secondly, in the Gulf of Finland, the great irregularities are *lasting;* they were observed in 1750, in 1860, and will be there to-day; while the disturbance for Ino's time, marked near Morioka, according to Dr. Naumann's own sketch, has *disappeared entirely*.

The method employed for drawing curves exactly according to the values found must lead to unsatisfactory results, if the probable error is large in comparison with the quantities determined, as is the case in all three instances which I mentioned.

To Mr. Knipping's renewed objections, Dr. Naumann further replied:—

1. The map accompanying the paper has been designated by myself: "a mere illustration to the notes." Having said in these notes: "the curves follow a crooked line and their course appears to conform to certain lines peculiar to the configuration of the Japanese Islands," it may be easily decided whether it would have been reasonable or not to "suppress" the sinuations. Even a rough sketch of a crooked line cannot look regular. I should consider it a quite unusual method in physical science to reject observations or results at once because they appear "improbable on the face of them." When I was speaking of "the smaller-sinuations" I wanted to announce that there are smaller and larger sinuations in the map; the word small can therefore not be taken in an absolute but only in a relative sense.

2. The probable error of a number of values used for the construction of the Sado sinuation does not require special quotation, as it can be determined quite independently from my notes. I have said a number of values found by magnetometer measurement were used. It is generally known to what degree of correctness the declination must be determined with a magnetic theodolite. The maximum of the amplitude of daily oscillation is likewise known. It may be stated however that even an error of 10′ to either side would not be sufficient to make that irregularity which I called the Sado-sinuation disappear.

3. I have not said that the magnetic irregularities in Germany and in the Gulf of Finland ought to be compared with those in Japan. Though detailed magnetic maps are very scarce—those which are known show the existence of irregularities, this is what I pointed out. If it be admitted that the magnetic curves are subject to irregularities in their course,

it may be expected that these irregularities will be found of a different character and of different extent in different parts of the world.

4. The probable error is not large in all cases, but it is very small in a number of cases. Altogether the map in question does not pretend, standing by itself, to offer final results; it is much more intended to be an inducement to future observations, by which alone the distribution of magnetism in Japan can be shown in an accurate and definite way.

MONOGRAFÍA GEOLÓGICA

DEL VOLCAN DE ALBAY

ó

EL MÁYON,

ESCRITA POR

ENRIQUE ABELLA Y CASARIEGO

Ingeniero Jefe del Cuerpo de Ingenieros de Minas, Jefe de Admon. Civil de 2.ª clase, Comendador de número de la Real y distinguida órden de Isabel la Católica

è individuo de la Sociedad Seismológica del Japon.

(Publicado por la misma.)

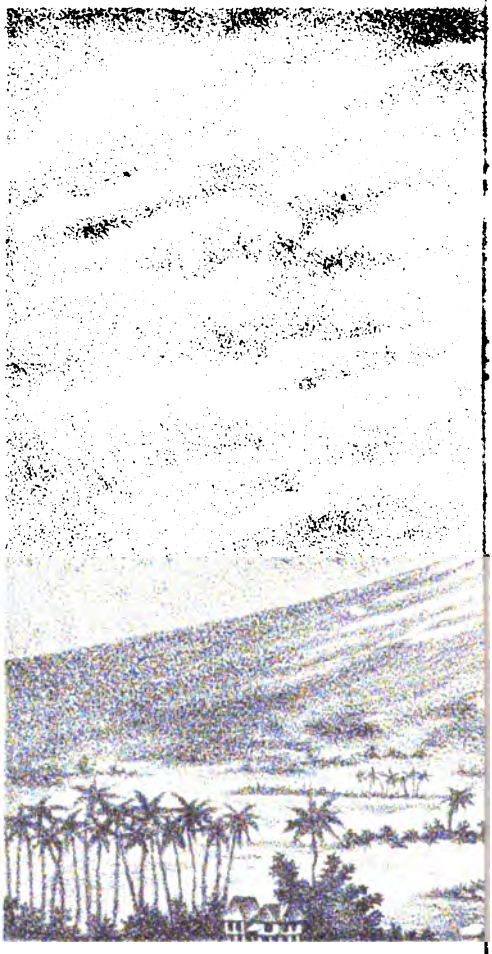
Á LA SOCIEDAD SEISMOLÓGICA DEL JAPON.

Forman uno de los objetos de esta Sociedad, á la cual me honro en pertenecer, los estudios que se refieran á fenómenos volcánicos. No es extraño, pués, que autorizado por un acuerdo del Gobierno Gral. de estas islas, le dedique este pequeño trabajo, que he tenide ocasion de hacer, sobre el mas importante de los volcanes activos de la isla de Luzon, el gran Máyon de la provincia de Albay.

Enrique Abella
y Casariego.

Manila, Abril 1° de 1882.

Read May 30th, 1882.



1. Cerro Linyion = 2-L

EL MÁYON.

En el estremo S. E. de la isla de Luzon, se alza aislado y magestuoso, el monte volcánico Máyon, en forma de inmensa tienda de campaña cónica, teñida de un color gris violáceo con manchas blanquizcas y surcada por multitud de barrancos negros y rectilíneos que se retuercen en curvas mas ó menos marcadas al acercarse á la emboscada base de la montaña, que se presenta, además, coronada de un inmenso y prolongado penacho blanco que, á manera de enorme catavientos, se estiende y abate impulsado por las fuertes corrientes de aire que suelen reinar à la altura de 2.734^{m} que su cúspide alcanza[1].

De noche, el espectáculo con la eruption actual, es mas hermoso todavia. Desde Albay, Legaspi ó Daraga, la silueta inmensa del monte se destaca en negro, sobre un fondo azul oscuro salpicado de estrellas, cuyo centelleo apénas se distingue, al rojo y vivísimo resplandor de las lavas incandescentes que magestuosamente asoman á través de las enormes grietas superiores del cono, que parece entreabrirse descubriendo su interior ardiente como el de un alto horno. Las lavas descienden apelmazadas y perdiendo brillo hasta que, decrepitando y subdividiéndose al chocar entre sí ó con las aristas y salientes de la ladera, vuelven à encenderse con mas fuerza y deslumbramiento, asemejándose entónces á una soberbia cascada de fuego que se pierde en las laderas inferiores; oscureciéndose luego el monte durante algunos segundos ó minutos, para volver à iluminarse de nuevo, cuando la lava alcanza otra vez los puntos de salida.

Esta hermosa montaña es muy conocida en Filipinas por su magnitud, por la regularidad de su forma y por la triste celebridad de los estragos que, en sus erupciones mas fuertes, ha

(1) Segun Jagor y segun la carta de la Com. Hidrogr. de marina 2622^{m}.

causado y causa todavia á las numerosas y ricas poblaciones que se extienden alrededor de su base; apesar de lo cual, apénas puede conocerse la verdadera historia de las mas importantes fases de su actividad volcánica, porque no existen noticias anteriores á la conquista del Archipiélago, y las posteriores solo se refieren á las mas grandes catástrofes ocurridas.

Erupciones.

Segun los datos que hemos podido consultar sobre este interesante asunto, la erupcion del Máyon mas antiguamente conocida, se refiere al año 1716, sin que se tengan detalles sobre su entidad; pero el dia 20 de Julio de 1766 se cita otra, al parecer mas considerable ó tal vez mas detalladamente descrita, en la que apareció la cúspide del cono completamente incandecente, viéndose descender hácia el oriente una gran corriente de lava durante 6 dias consecutivos.

Tambien se cita la fecha del 23 de Oct^{e} del mismo año como la de otra *erupcion horrorosa*[1] que en pocas horas asoló el pueblo de Malínao y causé grandes estragos en los de Albay, Cagsáua, Camálig, Budiao, Guinobátan y Ligao; pero este desastre debe en nuestro concepto atribuirse, no á los fuegos subterráneos del Mayon, sino à la gran cantidad de materiales incoherentes que sus laderas contienen, los cuales fueron arrastrados à las llanuras de los pueblos inmediatos, y con gran violencia, por una de esas terribles tempestades giratorias que en el pais se llaman *báguios*. En las descripciones de aquella época se lee, en efecto, que, al mismo tiempo de la *erupcion horrorosa*, se manifestaba una fuerte tempestad por el O. N. O. *que roló* al Sur, expeliendo el volcan *tal cantidad de agua* que entre Líbog y Albay, corrieron rios de mas de 30 varas de ancho y, hácia el S. O., quedaron los cocoteros y otros árboles sepultados hasta sus copas.

En el año 1800 tambien se cita otra considerable erupcion que causó así mismo bastantes desgracias; pero la que se manifestò el 1.° de Feb.° de 1814, es la que ha dejado mas profundos y dolorosos recuerdos, por la imponente magnitud del

(1) Estado geográfico de los PP. Franciscanos.

fenómeno y los estragos que causó. El Párroco entónces del pueblo de Guinobátan, testigo presencial de aquella catástrofe, la refiere en estos términos[1]: "Precedieron, la noche ántes, "repetidos temblores; siguieron por la mañana del dia 1.° con "un fuerte sacudimiento á lo último, è instantáneamente arrojó "por su boca como una nube que subia piramidal y formaba la "figura de un penacho muy vistoso[2]. Como el sol estaba claro, "presentaba diversas vistas el fenómeno asolador. El pico negro "iba hácia arriba en sombrío, su medio en varios colores y su "estremo estaba de color ceniciento. Mas á poco de estar "observando este objeto, se sintió un gran terremoto seguido "de fuertes truenos. Seguia asi arrojando lava[3] con violen- "cia, cuando á poco se extendió la nube que formaba: oscureció "la tierra, incendió la atmósfera, y de la tierra se veian salir "rayos y centellas que se cruzaban unos con otros, formando "una tempestad horrorosa. A esto se siguió instantáneamente "una lluvia tan terrible de gruesas piedras encendidas y "calcinadas[4] que arruinaban y quemaban cuanto encontraban. "Poco despues piedras mas chicas, arena y ceniza; durando esto "mas de tres horas y la oscuridad como cinco. Abrasó y "arruinó enteramente los pueblos de Camálig, Cagsáua y Budi- "ao con la mitad de Albay, lo mismo el de Guinobátan y ménos "el de Bulusau por no correr hácia estas partes tanto la erup- "coin, y porque el viento le dió la direccion al S. La oscuridad "llegó à partes bastante distantes como à Manila è Ylocos, "pasando la ceniza, como aseguran algunos, hasta China, y los "truenos se oyeron en muchas partes del archipiélago"[5].

Humeando mas ó menos, permaneció tranquilo el Mayon, terminada esa erupcion, hasta el año de 1827, en que comenzó

---

(1) Estado geográfico etc. de los P P. Franciscans, pàgina 255.

(2) El llamado *pino* volcánico que caracteriza el comienzo de la fase *explosiva* ó pliniana.

(3) Nótese que se llama *lava* la nube de vapores y cenizas que formaban el *pino volcánico*.

(4) *Bombas volcánicas* que se ven hoy en las llanuras del S y del S. O. del volcan y que por su gran tamaño y aristas vivas, debe suponerse que no fueron transportadas por las aguas. Tambien existen en la isla de San Miguel, al E. de Tabaco.

(5) En estas apreciaciones es posible que haya alguna exageracion, porque, reinando entónces la monzon del N. E., las cenizas no pudieron pasar por Manila y llegar á China.

á manifestarse otra no tan ruidosa, que duró hasta principios del año siguiente.

En 1834 se manifestaron corrientes de lava incandescente que, desde la cúspide, bajaba en todos sentidos á lo large de los barrancos superiores; permaneciendo en este estado, con períodos de aumento ó disminucion, hasta el mes de Mayo del año siguiente, en que durante algunas horas se vió una erupcion de piedras y cenizas lanzadas solo à pequeña distancia de la cumbre, oyéndose al mismo tiempo un ruido semejante al de un fuerte trueno.

El 21 de Enero de 1845 se oyó nuevamente un ruido fuerte subterráneo, manifestándose una erupcion de unos diez minutos, que se repitió un cuarto de hora y una hora despues, apareciendo luégo una nube de cenizas que cayeron sobre Camàlig y Guinobátan á donde el N. E. las impulsaba. Se oyeron durante algun tiempo ruidos subterráneos, que de dia, se asemejaban al de multitud de piedras que chocasen entre sí, y de noche, al de una lejana cascada. Estos fenómenos fueron debilitándose poco à poco hasta terminar por completo al cabo de una semana, sin que esta erupcion hubiese que lamentar ninguna desgracia personal.

En el año siguiente de 1846 ocurrió tambien otra erupcion, y en el de 1851 se observaron otras dos insignificantes de cenizas.

El 13 de Julio de 1853 se anunció una gran erupcion con ruidos considerables subterráneos, pero sin terremotos; manifestándose en efecto à medio dia una alta columna de ceniza en forma de árbol; viéndose rodar al mismo tiempo, hasta el pié de la montaña, piedras incandescentes que destruyeron muchas casas, produciendo la muerte de 33 personas. Quedaron, todos los pueblos de la base del volcan, recubiertos de una capa de ceniza, apesar de que el fenómeno duró solo hasta la tarde.

En todo el año de 1858 se manifestó casi sin interrupcion una suave deyeccion de lavas que, en las noches claras, se veian correr incandescentes por las vertientes de la montaña.

En las noches despejadas de los años sucesivos, se observaba á veces cierto resplandor en la cumbre; pero no volvió á manifestarse una verdadera erupcion, hasta el 8 de Dic^{e} de 1871. Amaneció el dia percibiéndose algunos ruidos subter-

ráneos, y habiéndose oido tres muy fuertes entre siete y ocho, se vió en la cúspide del volcan una gruesa columna de humo que, elevándose magestuosamente á bastante altura, fué esparciéndose y descendiendo lentamente; notándose en seguida la salida de cenizas, arena y lavas, arrojadas con poca violencia, ó impulsadas las primeras por el viento N. E. hacia Camàlig y Guinobàtan, en cuyos pueblos tenian que andar con luces, huyendo muchos habitantes hácia los cerros del O: tal era la cantidad de cenizas que caian, y entre ellas algunas pelotillas de lodo del tamaño de balas de fusil y mas pequeñas. A las diez, comenzó á despejarse, dejando sobre los campos y tejados una capa de ceniza que tendria un espesor de 4.^{mm} A la una de la tarde, recrudeció la erupcion con fuertes detonaciones y relámpagos, y por la noche pudo ya verse el monte iluminado por los surcos de lava que descendian hácia la parte de Albay y Legaspi, arrollando toda la vegetacion recrecida en los 12 años de calma que se habian esperimentado. Las aguas de los rios de Camàlig y Guinobàtan y el Quinali, se tiñeron de un color plomizo semejante al de las cenizas que llevaban en suspension. En la visita de Bocton hubo dos personas asfixiadas, y una quemada en la de Buyuan.

El 31 de Oct^{e} de 1875, que algunos citan tambien como fecha de otra erupcion, solo se experimentaron, segun todas las apariencias, los efectos de un fuerte báguio sobre el inmenso condensador, compuesto de materiales incoherentes, del cono volcánico. Causó sin embargo 1500 víctimas y enormes destrozos materiales, mayores que los de las erupciones volcánicas conocidas. El Sr. Drasche refiere este hecho como un ejemplo de lo difícil que es conocer bien ciertos hechos, aún en los puntos mas cercanos de donde ocurren, puesto que, segun dice, se atribuyeron en Manila à los fuegos del volcan el desastre de 1875; y efectivamente, aún en el mismo Albay, no faltaron personas que nos aseguraron que el volcan tuvo una verdadera erupcion, al mismo tiempo que el temporal.

Diez años permaneció el Máyon tranquilo y silencioso, hasta que, en la noche del 6 de Julio de 1881, apercibieron los habitantes de Tabaco, apesar de la lluvia que caia à torrentes, un resplandor vivísimo hácia la cumbre del monte, que solo

hoy hácia el S. y S.S.E. de las vertientes, algunas de ellas *muy bajas*, casi en la mitad de la altura del cono.

En nuestro concepto, tanto la misma abundancia de los puntos de salida de la lava, que la hace repartir sobre una gran superficie de las laderas, como el estado incoherente de ella, que facilita su transporte y arrastre, favorecido ademas por la empinada pendiente del cono, hacen que no puedan conservars los conos parásitos, accesorios ó subordinados que equivocadamente echa de menos Drasche en la mayor parte de los volcanes de la isla de Luzon[1]

Veamos ahora la constitucion hidrográfica y orográfica del Máyon.

Hidrografia.

La region orográfica de este monte está limitada principalmente por los rios Quinali de Tabaco, ó del N., Quinali de Ligao ó del S., el Paùlug y el Yána. Los mas importantes por su caudal y por las regiones orográficas que entre sí separan son los dos Quinalis.

El primero nace, entre Guinobàtan y Camàlig, de varios arroyuelos que unos vienen de las faldas del Máyon, en direccion N. à S., y otros de la falda occidental del monte Quiluinan, en direccion contraria; corriendo luego al O. N. O., y desaguando en la laguna de Bato de la provincia de Camarines Sur, con caudal y cauce ya suficientes para permitir la navegacion en bancas desde Polangui. La comarca que baña este rio se llama partido de la Yraya, que ha side por cierto generalmente el mas castigado por las erupciones del volcan.

---

(1) En efecto, de los volcanes que hemos tenido hasta ahora ocasion de ver, aunque no de estudiar todavia, podemos citar en 1er término el gran Banàjao que, hacia la parte de Lucban, tiene el cono subordinado llamado el Banajillo, y tal vez por un estudio detenido pueda tambien considerársele subordinado el S. Cristóbal; el Maquíling que tambien los tiene hacia el barrio Biting de Bay y hacia los Baños; las numerosas bocas volcánicas que existen entre el S. Cristóbal y el Maquiling, en la comarca de Yum Calanan y S. Pablo; y probablemente tambien en otros muchos volcanes que han sido muy poco estudiados hasta ahora; pero de todas maneras, los ejemplos citados prueban que el hecho no es tan generalmente característico de Luzon como supone Drasche, y esto confirma, una vez, mas lo espuesto de ciertas generalizaciones teóricas sobre paises poco conocidos y materias tan delicadas.

ION OROGRAFICA

DE ALBAY.

El Quinali de Tabaco, al N., y el Paùlug, al S., corren en opuestas direcciones, formando una estrecha garganta que separa las masas montañosas del Mayon y el Masaraga, y por ella sigue el camino de herradura que une entre sí los pueblos de Tabaco y de Ligao.

El primero de esos rios, tiene su fuente principal en una pequeña laguna del Masaraga, y, bajando hacia el N E., desemboca en el mar, muy cerca del pueblo de Malínao, con un cauce y un caudal de aguas tambien muy considerable, pues recoge gran parte de las de la falda N. del Máyon y casi todas las de la parte oriental del Masaraga.

Muy cerca de la importante visita de S. Antonio, en un barrio que se llama Tancalao, existe una fuente ferruginosa que ha adquirido cierta nombradía por haber producido sus aguas, usadas en bebida, algunas curas en ciertas enfermedades. Brota en la ladera izquierda del rio, frente á un mogote volcánico situado en la opuesta márgen, y sus aguas, de un marcadísimo sabor estíptico antes de mezclarse con las del rio, dejan sobre la dolerita un considerable manchon de óxido férrico hidratado. Esta dolerita, en las cercanias del manantial, se presenta algo descompuesta, tanto por los efectos metamórficos actuales, de las aguas ferruginosas que la penetran en varios puntos, impregnándola fuertemente de óxide férrico; como probablemente tambien, por la accion que han debido producir sobre ella las rocas volcánicas y vítress del mogote Tancalao.

En este punto se observa un curioso cambio de direccion del rio, producido probablemente por alguna de las erupciones del Máyon. Al salir del barrio S. Antonio, para ir à Tancalao, hay una bajada, formada por un cantil que, casi limitado hoy en aquella parte por el arroyo que baja de Buhían, se dirige al O.S.O., por el Bantayan, ye se reune por fin al cantil que forma allí la márgen derecha del rio Quinali. Este cantil señala indudablemente la antigua márgen del rio, que dejaba, pues, á la izquierda el cerrillo Tancalao que pertenece, por lo tanto, á la region orográfica del Masaraga, aunque hoy parezca pertenecer à la del Máyon. Esto no quiere decir, sin embargo, que no pueda haber provenido de alguna boca subordinada á este último volcan.

El rio Paúlug es de menos importancia que el que acabamos de considerar, ye corre en direccion N. E. à S. O. Nace en la misma garganta por donde pasa el camino de Ligao y Tabaco, y desemboca en el Quinali del S.

Por último, el rio Yána está formado por la reunion de dos arroyos que bajan respectivemente del Máyon y de los montes Quituinan y Oag, en direcciones opuestas de N. y S., corriendo hácia levante, luégo que se reunen cerca de Malápod, para formar el Yána, entre el cerro Lingion y el Máyon, desembocando al N. de Legaspi en el seno de Albay.

Uno de sus afluentes, el llamado arroyo Busay, presenta cerca del puente de la calzada de Daraga á Camàlig una hermosa cascada de poca altura, pero de abundante caudal de agua. El otro, que baja del Mayon y que pasa muy cerca de las ruinas del destruido y no reedificado pueblo de Budiao, recoje las aguas de un abundante manantial sulfuroso, ligeramente termal, que posee, segun se asegura, propiedades medicinales. Analizadas en 1850 estas aguas, por D. E. Robertus, dieron el siguiente resultado:[1]

Cloruro de sodio	0'579.
Sulfato de cal	0'403.
Carbonato de cal	0'314.
Hidrógeno sulfurado	0'283.
Agua	998'421.
	1000'000.

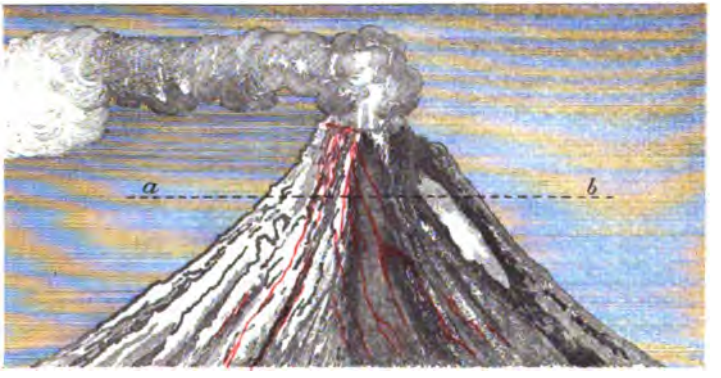
Además de estas corrientes, que limitan el macizo montañoso del Máyon, existen una multitud de barrancos y arroyos radiales, casi rectilíneos cerca de la cúspide, dada la regularidad de la forma cónica del monte; que mas abajo se recurvan para desembocar en las citadas corrientes principales ó en la mar. Entre ellos los mas notables son el Bulauan, el Parel, el Cagbájai y el Bigá que desembocan en los senos de Tabaco ó de Albay.

Orografia.

La orografia del Máyon tomada en conjunto, es bastante sencilla, puesto que su forma cónica, que hemos comparado à la

(1) Estado geográfico etc. pagª 272.

3.



LOS PUNTOS Y TRAZOS ROJOS REPRESENTAN LAS LAVAS INCANDESCENTES.

de una inmensa tienda de campaña, sorpende por su regularidad y aislamiento. Sin embargo, observado con detencion, presenta algunas pequeñas irregularidades orográficas á él subordinadas, como son las colinas comprendidas entre los rios Bulauan y Dugàs y los cerros aislados de Tancalao, al N., y Lingion, al S.

La parte superior del cono, mirada à simple vista, termina casi en punta; pero observada con alguna detencion, y sobre todo con un buen antejo desde Legaspi, Albay ó Daraga, se ve un pequeño truncamiento en forma de media luna, con dos eminencias; de las qué la del O. (izquierda del dibujo 3) es la mas alta, constituida por un potente lastron inclinado, cuyo asiento despide vapores blancos. Hácia al E., (parte de la montaña que mira á Líbog) se ve asomar un cono rudimentario que humea, detrás del encostrado blanco que por aquella parte se ve, producido probablemente por la kaolinizacion de los feldespatos y produccion de sulfato de cal á favor de los vapores sulfurosos y cal contenida en las lavas doleríticas y basálticas. Debajo de la eminencia mas alta ó lastron inclinado, se distingue, aun á simple vista, un enorme pilar que, rodeado así mismo de una costra blanquizca, se asemeja á la torre de una iglesia, rodeada de blanco caserio. Este pilar, en el dibujo sacado por Drasche en Abril de 1875, lo representa[1] muy cerca de la cumbre, lo cual parece indicar que desde el principio de la actual erupcion, comenzada, como hemos visto, en Júlio del año anterior de 1881, el cono ha aumentado en altura toda la parte superior à la linea *a b* de nuestro dibujo; cuyo hecho no es inverosímil, aunque parece que debiera haber ido acompañado de cierta fuerza eruptiva, que no parecen haber observado los habitantes de los pueblos de la falda.

Las colinas del N.E., que dominan al pueblo de Malilípod presentan dos ó tres cumbres en série lineal, de formas cupuloides que lo mismo pueden atribuirse á conos parásitos, modificados por las erosiones considerables del Máyon, que á una ó varias potentes corrientes de lava que se hubieran insinuado en aquel sentido; semejantemente á lo que Drasche supone en las

(1) Bol. de la Comn del Mapa Geol. de España. Tomo 8.°, cuadº 2.°, pagª 337 (69).

colinas que se encuentran al O. de los volcanes apagados Yriga y Malínao.

El cerro Tancalao, situado al S.O. de la visita de San Antonio jurisdiccion del pueblo de Tabaco, dijimos ya que presenta la forma de un mogote, aislado entre el caúce actual y el antiguo del rio Quinali del N., formando hácia este último, un tajo vertical ó acantilado, al pié del cual pasa el camino de Tabaco á Ligao.

De forma análoga, aunque de masa un poco mas considerable, se presenta el cerro Lingion al N. de Albay y Daraga, al pié del Mayon y á él subordinado; sin que pueda explicarse su formacion, lo mismo que la del Tancalao, mas que suponiendolos restos de conos volcánicos subordinados, pues las acciones atmosféricas de por sí solas, áun actuando sobre los materiales sueltos, que Drasche supone que componen la totalidad de esta colina, difícilmente llegarian á formar nunca un mogote tan aislado y de tanta consideracion como el Lingion. Puede verse en la vista general del Máyon que acompaña à esta Memoria. el aspecto y proporciones de esta colina.

Geologia.

La composicion petrológica de esta montaña es bastante uniforme, como generalmente sucede en todos los volcanes ó regiones de composicion volcánica, sobre todo si, como acontece en el Mayon, la composicion ó distribucion interior de los diques y capas de las diversas eruptiones, no pueden estudiarse en el mismo monte, por la falta de uno de esos barrancos profundos, como los clásicos del Bove en el Etna y el de las Angustias en Palma. La hermosura y regularidad misma del Mayon, ocultan hoy por hoy los detalles de su estructura ó esqueleto interior; pero no perdemos la esperanza de allegar tal vez algunos detalles más de los que hoy conocemos, si volvemos á visitar este sobérbio coloso, en meses y dias mas apropósitos y convenientes para su estudio que los de que pudimos disponer en nuestra visita de los últimos dias de Dic^{e} dil año anterior[1].

[1] Reinando entonces con toda su fuerza la monzon del N. E. que directamente azota toda aquella costa, los caminos secundarios y mucho mas los barrancos y laderas del monte, estaban intransitables y a veces.

Tomado en conjunto, el Mayon se compone de rocas esencialmente basálticas, formadas de feldespato y augita, como elementos dominantes que imprimen carácter á las masas pétreas del monte; ya compactas, en los diques; ya lávicas ó esponjosas, en las corrientes de lava; ó ya escoriformes y metamorfizadas por la accion de los manantiales gaseosos ácidos del mismo volcan, en las deyecciones actuales.

Las lavas fragmenticias que actualmente arroja, presentan variedad de aspectos petrológicos. Como tipo mas flúido hemos recogido, todavia caliente, en el barrio de Bucton, una lava basáltica esencialmente augítica y algo escoriforme, que casi puede designarse con el nombre de escoria, aunque no tan esponjosa y tan característica como las que se encuentran por ejemplo en el volcan de Taal.

Tambien arroja numerosos conglomerados que llamamos lávicos, para indicar su formacion en trozos de verdadera dolerita compacta; á veces de gran tamaño, envueltos en otra lava basáltica semivitrificada que ha servido de cemento, pero *por la via ignea*, para distinguirlos de los conglomerados de materiales volcánicos sedimentados ó depositados por la accion del agua. En estos conglomerados, se observan sobre la dolerita, que es la roca más feldespática, costras de yeso cristalizado, cristalino y fibroso, formado por la accion de los gases sulfurosos sobre la base calífera del labrador, y aun de la augita; como un curioso efecto de la accion metamórfica actual de los gases volcánicos, sobre las rocas tambien volcánicas.

Se presenta tambien á veces la dolerita muy descompuesta y kaolinizada, notándose en este caso que apénas se forman las costras de yeso, sin duda porque la descomposicion se ha hecho bajo la accion de otra clase de vapores que producen otros compuestos.

Las doleritas compactas y poco descompuestas, que forman algunos de esos conglomerados lávicos, parecen revelar que han

---

completamente inaccesibles. En nuestra ascension, el viento fuertísimo, la lluvia y la multitud de sanguijuelas que se nos pegaban en todo el cuerpo, aumentaban la enorme fatiga de la subida, por pendientes de 30.° y 40.°, é impedian hacer buenas observaciones. En tiempo seco (Abril y Mayo) solo hay que vencer la fatiga natural de la difícil subida.

sido arrancadas de las paredes de los conductos volcánicos, cementándose en la lava escoriforme vitrificada que los envuelve, y permaneciendo muy poco tiempo en este estado, dada su escasa descomposicion; así como los trozos mas descompuestos han sentido la influencia del calor y de los gases de las lavas, permaneciendo mas tiempo en los espresados conductos interiores.

El estado pastoso, semisolificado en que las lavas se presentan puede esplicarse suponiendo que el laboratorio volcánico de donde proceden, está situado á gran profundidad, enfriándose ó solificándose considerablemente, ántes de llegar, con alguna lentitud, á la superficie de las laderas ó bocas de deyeccion.

Esos mismos conglomerados, parecen tambien demostrar que, el esqueleto del Máyon, está formado esclusivamente de doleritas, que son las rocas arrancadas de las paredes interiores; y que el tipo mas verdaderamente basáltico proviene de las erupciones mas modernas ó contemporáneas.

Las doleritas son exactamente iguales á las que presenta el Súngay y el Taal en Batangas, y mas especialmente á las del Maquíling; y segun Roth, que vió los ejemplares recojidos por el viagero Jagor, son tambien idénticos á las del Etna, hasta el punto de no distinguirlas entre sí. Están compuestas de feldespato labrador y augita, con algunos granos de olivino y hierro magnético; presentándose de un color gris ó rosácea y á veces hermosamente porfídicas, en cuyo caso los elementos accesorios casi desaparecen.

Sin embargo, en nuestra ascension, hecha por la parte del E.N.E., en la jurisdiccion del barrio Bonga, encontramos á 1000 y 1500^{m} de altura, en el caúce del rio Bulauan y de los arroyuelos afluentes que tuvimos que atravesar, un basalto lávico un poco celuloso, pero no escoriforme, en algunos parages y con carácter porfídico; constituyendo una verdadera basanita que, por el yacimiento, parecia constituir una no muy antigua corriente de lava.

Subiendo el monte(1) se encuentran en primer término,

(1) Drasche cita solo la ascension de dos Escoceses, la del viagero Jagor, y la súya propia; y como ésto podria hacer creer á muchos, que nádie más habia subido al volcan, debemos manifestar que ya en 1692 se cita la

con suavísimas pendientes, capas de arenas sueltas puramente volcánicas, separadas de trecho en trecho por una especie de lechos de cantos mayores, de suerte que figuran una especie de peldaños espaciados de 50 á 30 metros, los cuales han debido evidentemente formarse por avenidas y erupciones sucesivas.

Mas arriba, la pendiente va pronunciándose, y los materiales de las arenas se hacen mayores; desapareciendo á los 600 metros la region cultivada[1], que se sustituye por el bosque maderable. Sucesivamente se va éste haciendo mas claro y mas raquítico, y se presenta el suelo mas compacto, con las corrientes de lava que hemos indicado mas arriba.

A los 1500 metros de altura sobre el nivel del mar, la vegetacion está casi esclusivamente compuesta de altas yerbas, y la pendiente de las laderas es pronunciadísima y sumamente fatigosa. Sobre la masa basáltica del lecho del rio Bulauan, se ven en sus laderas materiales gruesos incoherentes, de la misma naturaleza que los recojidos en Bucton à 700 metros de altura, con la diferencia de no encontrar en aquellos los encostramientos de yeso que en estos se observaban con abundancia.

Más arriba, los materiales sueltos van siendo mas numerosos y mas variados, aunque todos ellos revelan por su aspecto exterior, generalmente recubierto de una capa de óxido de hierro pardo, que no son productos de muy modernas erupciones; lo cual tambien comprueba la vegetacion existente, que, aunque raquítica, llega por aquella parte hasta muy cerca de la cumbre[2]

---

ascension de dos P P. Franciscanos, uno de los cuales encontró *dos bocas*, que le impidieron avanzar, y el otro recogió una buena porcion de *azufre*. El 11 de Marzo de 1823, el Capitan Don Antonio Sigüenza, subió tambien al volcan, obteniendo por este hecho una medalla de la Sociedad Económica. Por último, en los pueblos que rodean al volcan, viven algunos Españoles y muchos Indios que han llegado á la cumbre en épocas de tranquilidad volcánica.

(1) Es necesario no olvidar que nos referimos al N. E. de la montaña; hácia el S. la parte cultivable esta mas baja.

(2) Este hecho lo hemos comprobado personalmente sin embargo, el Señor Drasche dice (Bol. T.° 8°, pag.ª 334): " Pasando al pié del Albay, tuve ocasion de examinar atentamente la montaña por su *parte oriental*. El bosque apénas alcanza aquí la cuarta parte de la altura y siguen hasta la cumbre montones de escorias." Es posible que este hecho se refiera *á la parte meridional* por donde subió, y en la que efectivamente se verifica esto.

El estudio de esta cumbre no ha podido hacerse, hasta el presente, ni aun por aquellos que la han alcanzado en épocas de tranquilidad volcánica de la montaña; pero por sus confusas ó muy concisas descripciones parece deducirse que no existe un verdadero cráter en forma de caldera, y que si ha existido, probablemente ha debido rellenarse por los materiales del interior que, lanzados con escasa violencia y en sentido muy vertical, han podido caer nuevamente dentro, obturando el cráter. Lo que hoy puede verse, ya sea desde cualquiera de los pueblos de la falda, ya desde la ladera misma, donde nosotros lo contemplámos bastante cerca, es una especie de enorme criba, formada por una escombrera de grandes cantos, amontonados en desórden por entre los cuales salen numerosísimos dardos de vapores que reunidos forman el inmenso penacho del volcan; pero parece indudable que la lava solo la emite ya, á lo menos en la actual erupcion, por las bocas secundarias ó hendiduras del S. de la montaña; y probablemente ha debido suceder lo propio en las últimas erupciones anteriores, si se atiende al estado de la vegetacion de las laderas hácia todos los rumbos.

Así como, hácia el S., la vegetacion termina à unos 700.^{m} de altura sobre el nivel del mar, acabamos de ver que, hácia el oriente llega hasta muy cerca de la cumbre, y otro tanto sucede hácia el N. y hácia el O.; indicando esto que los productos de las erupciones, hace mucho tiempo que no salen en esas direcciones, y que, por lo tanto, si la salida de los materiales interiores persistiera en el mismo sentido en que hoy se emiten, la montaña avanzaria sobre el mar hacia el seno de Albay. Además, esta persistencia en la salida de las lavas hacia el S., demuestra que la ladera del N. es mas resistente y se han solidificado y rellenado todas sus grietas; ó bien que el conducto ó chimenea volcánica presenta un buzamiento hácia el N. que con el tiempo destruirá la actual regularidad de la montaña.

En cuanto à la composicion de los cerros aislados de Tancalao y Lingion, el primero, además de contener una dolerita idéntica á la del Máyon, presenta un feldespato blanco mate, en fajas ó capas que parecen concrecionadas, con cristalillos de mica negra y algunos que parecen de broncita; y un dique, formado de una retinita gris, con venillas negras en dos

sentidos casi perpendiculares, de una especie de obsidiana, y cristalillos, tambien de mica, interpuestos en la masa total, resquebrajada de tal modo que, deshaciéndose en granillos, tal vez pudiera clasificarse mejor como una verdadera perlita ó galliacea, teniendo en cuenta su índole basáltica.

El cerro Lingion está esencialmente compuesto de doleritas lávicas oscuras, de las que forman un tránsito al basalto. En la superficie, se encuentra gran cantidad de rapilo, formado de feldespato, y numerosos cristalillos de augita; pero no está solo y esclusivamente compuesto de estos materiales incoherentes y deleznables, como Drasche supone[1], atribuyéndoles el orígen de la forma de esta colina, puesto que, en algunos barrancos, se descubren las doleritas lávicas que hemos indicado y otras rojas escoriformes. Por otra parte, ya dijimos antes que no se comprende como, aun suponiendo que estuviera compuesto de ràpilos, ha podido llegar á adquirir la forma cónica que esta colina presenta.

En cuanto á los cerros que forman y rodean al actual emplazamiento del pueblo de Cagsáua (Daraga), y los que forman la baja y pequeña península de los pueblos de Bacacay y Líbog, estan compuestos de tobas volcánicas, peperinos y brechas de cantos y elementos dolerítico, empastados en una especie de arcilla gris, exactamente igual á las cenizas del volcan, oxidada en muchos puntos y convertida en una especie de ocre pardo ó amarillento. La existencia de estas colinas debe pues ser posterior á la aparicion del foco volcánico del Máyon, á no ser que puedan relacionarse sus materiales á los focos ya apagados del Masaraga ó Malínao. Este hecho, solo podrá verificarse en el supuesto de que las rocas volcánicas de estos últimos focos estinguidos, presenten un tipo ó composicion distinta de las que caracterizan al Mayon.

Por lo que se refiere á la clasificacion del estado de actividad de este volcan, si bien presentaria cierta utilidad práctica, para calcular el peligro de las poblaciones que le rodean, no creemos que sea fácil de hacer, con los actuales conocimientos, sobre esta delicadísima rama de la geología moderna. Drasche,

(1) Bol. de la Comn del Mapa Geol. de España T.° 8.°, pagª 338.

admitiendo los periodos de actividad volcánica que Stör distingue, supone que el Máyon ha entrado en el 2.°, ó sea en él de derrame de torrentes detríticos de lava[1]

No sabemos hasta que punto puede ser generalmente cierta esta clasificacion, puesto que, circunscribiéndonos á los estrechos límites de la historia conocida del Mayon, vemos que, unas veces ha presentado solamente ligeras erupciones de ceniza; otras esclusivamente derrames de lava; y, casi siempre, salida de ambos elementos eruptivos, pero en un órden inverso al que como mas general admite Drasche, es decir, precediendo las cenizas á la deyeccion de las lavas ó á los períodos en que redobla su actividad. Este hecho, puede esplicarse fácilmente, en el supuesto probable de que las cenizas volcánicas provengan de la trituracion ó rozamiento de las rocas que más ó ménos intercepten los conductos interiores, suponiendo que la primera fuerza impulsiva de la erupcion límpia, por decirlo así, los conductos atuidos, arrojando al exterior los materiales pétreos y pulverulentos que se producen.

Admitiendo, en todo caso, la clasificacion de Stopani, no para caracterizar el estado más ó ménos avanzado de decrepitud del volcan, sino como carácter ó *fase* de sus erupciones; podremos decir que la de 1814 presentó la *pliniana ó de explosion*, y que la actual puede designarse como de *deyeccion ó estromboliana;* presentándose en los períodos intermedios, de aparente tranquilidad, bajo la *fase* de *simples emanaciones ó de solfatara.*

Supone ésto que no vuelva ya á presentar jamás la fase explosiva ó pliniana? Nádie creemos que fuera capaz de asegurarlo, no solamente para este volcan, cuyas significativas deyecciones actuales y la presencia permanente de su inmenso penacho, nos avisan el peligro de tal suposicion; sino que en el mismo volcan de Taal, que Drasche supone en el 3.° de los periodos de Stör, y aun en el Maquíling ó en el Ysarog, que en todo el periodo histórico conocido, han permanecido en el mas absoluto silencio, y en cuyos cráteres existen árboles seculares que hacen retroceder mas la fecha de esa tranquilidad; pueden muy bien ocurrir todavia catástrofes desoladores, que

(1) Supone que el 1.° produzca solo deyeccion de lava y el 3.° erupciones de ceniza.

den el mentís mas absoluto á todas esas hipotéticas suposiciones; arrojando por sus antiguos cráteres, ú otros que al efecto se abran violentamente, torrentes de lava y de fuego, que siembren la desolacion y el espanto en las fértiles comarcas que les rodean.

Los pueblos situados en la base del Máyon, saben perfectamente la peligrosa vecindad del coloso que les domina, y sin embargo, su poblacion aumenta cada dia: y es que sus laderas alimentan una sobérbia y vigorosa vegetacion, que constituye la riqueza de la provincia; y presienten que, como dice Sir C. Lyell, de las calamidades que forman el obligatorio lote de la humanidad, las mas desastrosas, deben atribuirse á las causas morales, y no á las físicas; á los sucesos que el hombre hubiera podido domeñar, más que á las catástrofes inevitables que resultan de la accion subterránea.

ABSTRACT

OF A

MEMOIR

ON THE

EARTHQUAKES IN THE ISLAND OF LUZON IN 1880.

BY

DON JOSÉ CENTENO Y GARCIA,

ENGINEER AND INSPECTOR GENERAL.

TRANSLATED BY

PROF. W. S. CHAPLIN.

READ MAY 30TH, 1882.

SECTION I.

General Observations and Effects.

I.

Description of the Earthquake in Manila.

Since the remarkable catastrophe of 1863, which destroyed its principal buildings, burying under them many victims, this capital has enjoyed a relative rest which has been improved to develope the wealth of the country. The shocks of 1869 and 1872, not being accompanied by disastrous effects, did not retard this prosperity, and all who had lived here since that time saw with the utmost satisfaction the rapid progress which during the last ten years had been made in commerce, navigation, industry and even in the arts; but this lively satisfaction was imbittered from time to time by the recollection, the sad tradition, the quasi geological law, that from the conquest down to our days these phenomena at intervals of ten or twenty years neutralized by their fearful consequences the progress made in the mean time.

On the fourteenth of July 1880, at 12.53 at night, the first shock happened, and this, although short, was the most severe which had been experienced in Manila for several years. The motion was found to be in two directions, nearly at right-angles with each other, the first from South-east to North-west and the second from South-west to North-east, which seems to indicate the existence of two distinct foci of equal intensity of action, one in the second quadrant and the other in the third, since the amplitude of the oscillations recorded on the horizontal seismometer at the meteorological observatory of this capital were respectively 5° 25′ for the first, and 4° 58′ for the second. Figure 1, which together with the four following are taken from the publications of Father Federico

Faura, S. J., Director of the Meteorological Observatory, shows clearly the directions and relative intensities of the horizontal motions.

There was also in this earthquake some movement in the vertical direction, as the vertical seismometer moved through four millimetres of its scale.

Within an hour and a half after the first shock two new shocks were felt; these in Manila were unimportant, but in other places, as we shall see further on, they were more considerable, as in the provinces of Laguna, Morong and La Infanta, where during that night and the following day the recurrences were more frequent and the effect on buildings greater.

After this first shock, which, without producing great alarm in the vicinity, doubtless served as a salutary warning to take precautions which avoided greater misfortunes in the following shocks, the ground remained undisturbed during the 15th and 16th. On the 17th two slight shocks were again felt, which, although feebler than those of the 14th, indicated that the ground was not yet at rest; and indeed at 12.40 P. M. on the 18th, the fearful phenomenon was repeated in all its intensity, and in 70 seconds, which seemed however interminable, tumbled down a large portion of city and terrified the inhabitants, who, losing the innate confidence in the soil on which they stood, felt under their feet a force invisible, immense, mysterious, which in sepulchral silence with terrible might destroyed in a few seconds the work of many years, and threatened them with an instant and strange death. The inundation which rolls forward and engulfs thousands of people; the lightning which causes such terror and destruction with its thundering explosions and phosphoric light; the grand volcanic paroxisms with their flames and their showers of burning ashes which bury great treats of country, and with their rivers of lava which overwhelm and destroy everything in their paths; all these phenomena have a character of grandeur which, while it overpowers the mind, invites it to comtemplate them and charms it with their colossal splendor. All these phenomena offer to the imagination an imminent

danger, a death more or less probable, against which however there is always the hope of defending one's self. But the earthquake with its sombre silence, its unknown origin, its sudden and boundless effects, which may be a few cracks in the walls of buildings, or the disappearance of one or a hundred villages with all their inhabitants, this phenomenon so treacherous and at the same time omnipotent overwhelms the mind and leaves an impression never to be eradicated.

The pendulum of the seismograph at the "Ateneo Municipal" traced a line which indicated the motions of the ground, giving a figure so complicated that it is not possible to follow the line in its full extent, and even less to describe the complicated series of motions which caused it. We reproduce the figure (Fig. 2) from which may be seen the principal oscillations with their directions and relative intensities; and we copy entire the observations made and published by the observatory of the Ateneo Municipal on the 19th of July.

"July 18.—Sky covered with cirrus clouds all day; winds constant from the third quadrant; barometer rising; temperature moderate; evaporation 6.1 millimetres.

"*Note*:—At 12.40 in the night there was an earthquake which showed oscillation, trembling and what is commonly called rotation. It is not possible to record here all the movements of the pendulum, owing to their number and variety. To satisfy the desire expressed by many people we reproduce the figure described by the pendulum of the horizontal seismograph, which we think worthy of extended study. Today we limit ourselves however to the indications of the principal directions and amplitudes of the motions, leaving the remainder until the figure giving all the motions has been lithographed:—

"First maximum oscillation=from E. 5° S. to W. 5° N. Amplitude of the greatest oscillation in this direction is 22° in the slope of the seismic wave, 11° to the East, and 11° to the West.

"Second Maximum Oscillation = from South-west to North-east; amplitude 19°, but with the difference that the greater part of the motion 10° 10′ was towards the South-west,

and the remainder 8° 50′ towards the North-east.

"Third Maximum Oscillation = from N. 4° W. to S. 4° E., amplitude 16°, of which 9° was towards the South and 7° towards the North; consequently the impulse appears to have been from the North, towards the South.

"The index of the vertical seismometer was moved 34 millimetres from its position."

From the time of the heavy shock of the 18th until nine o'clock on the morning of the 19th according to the observations, there were felt many weak oscillations and shocks, all in directions from the South of East to the North of West.

Not only did the oscillations and shocks of little intensity continue until nine o'clock in the morning, the hour at which the observations cited ended, but they continued from that time almost without interruption, some easily perceptible, and others only recorded by the seismograph, until 3.40 o'clock on the afternoon of the 20th, when a new catastrophe came again to try our hearts, already disturbed, not only by the deep impression made by the former earthquake, but because the persistency of the motions and the continued vibration of the soil indicated clearly that under our feet that terrible motor, that mysterious force which in an instant might annihilate us, was still acting.

The violence and intensity of this second shock were greater even than of that of the 18th. And although the amplitude of the oscillation, as given by the record of the seismograph (Fig. 3), did not show as great an angle as the maximum of the 18th, the greater intensity ought to be attributed to this fact, that on the 20th the pendulum after starting was not allowed to finish its oscillation, but was forced to move in other directions without completing its curve on the plate, thus, as is clearly shown in the figure, the lines *aa*, *bb*, *rr* do not mark complete oscillations, but semi-oscillations. The pendulum, descending to the center of the plate with a velocity which would have raised it to a point almost as high as that reached on the other side, was moved by a force which not only destroyed the motion already possessed by the pendulum, but constrained it to ascend again to a height almost equal to

the first, which in reality represented an amplitude much greater than the 22° that had been recorded on the 18th.

The observations made at the meteorological observatory of the Ateneo describe the earthquake thus:—

"At 3.40 on the afternoon of the 20th strong shock felt; duration 45 seconds. First maximum oscillation; direction from S.E. 15° N., to N.W. 15° S.; amplitude 17°, of which 8° to the N. W. and 9° towards the S. E. Second maximum oscillation from S. E. 5° N., to N. W. 5° S.; amplitude 12°, of which 5° towards the E., and 7° towards the W. The index of the vertical seismograph was moved 22.5 millimetres from its position."

Some days after the earthquakes, the director of the observatory, Father Federico Faura, published a résumé of the observations in which this description was somewhat modified, as it was pointed out that the amplitude of the second maximum oscillation ought not to be 12°, but that this 12° was the amplitude of a semi-oscillation.

The pendulum continued during the remainder of the afternoon to oscillate in a way which was most disheartening to those of us who know that the instrument showed motions in the earth, although we could not perceive them. At 8 o'clock in the evening one of the vibrations was felt very perceptibly, and at 10.40 occurred the third earthquake with shocks more violent and irregular even, according to the feelings of many people among whom was the writer, than the former ones. Its duration was also greater than that of the earthquake in the afternoon, amounting to 55 seconds, and the vertical shocks moved the index of the vertical seismograph 28 millimetres instead of 24 as in the former case.

The situation could not be more trying; the shocks occurred more frequently; the intensity and violence of the motions increased; and many persons fearing any one of the thousand catastrophes which might happen, sought safety in boats on the river or bay. Considering the topographical situation of Manila, with the bay on one side and the lake *Bay* on the other, menaced thus by these two bodies of water which might in a few minutes inundate the whole low plain

which separates them, in which are placed the most considerable villages of the province, these precautions were very proper.

We give here the observations made with the seismograph of the Ateneo Municipal relating to the last earthquake, and published in the papers of the 22d.

"At 10.40 p.m. on the 20th a very heavy shock. Direction of the first oscillation S. W. to N. E. exactly, amplitude 17°, 9° to the S. W. and 8° to the N. E. Amplitude of the second oscillation 10° from E. to W. exactly, 5° to the E. and 5° to the W. Duration 55 seconds. The index of the vertical seismometer was moved 28 m.m."

In Fig. 4 may be seen the record left by the pendulum on the plate; and it is to be observed that, as in the two great earthquakes which preceded this one, the directions from the second toward the fourth quadrant are greatly in excess; so much so in the shock at 3.40 p.m. on the 20th, that this direction alone is observed, and in the last shock the two directions again appear as in the first of the series; with only this difference, that in the former the energy of the motions from the second to the fourth quadrants was greater than that of the motions from the first to the third, and in the latter the contrary was the case.

After this last great earthquake the vibrations of the earth gradually diminished until the pendulum stayed at rest for long intervals of time, a thing which had not been observed from the 18th until 3 p.m. on the 21st. These feeble shocks which were felt at irregular intervals, far from alarming us, rather reassured us, as their intensity became less and less and the intervals between them became greater and greater. Only at daybreak on the 25th a single shock was felt somewhat heavier than these others since the 20th, but this was without notable importance and left on the seismometer the curve represented in Fig. 5, in which only a single direction, that from the first towards the third quadrant, is seen; the direction from the second towards the fourth quadrant, which had been in former earthquakes the source of the most persistent and greatest motions, having consequently disappeared. The

amplitude of the oscillation in this last shock was only 4°, and the index of the vertical seismograph was only moved one millimetre.

In the latter part of July there was published, as we have before said, by the Director of the Meteorological Observatory a résumé of the observations made on the earthquakes between the 14th and the 25th of the month, in which after describing in detail the apparatus which had served to make the horizontal and vertical measurements, he proceeds to give an account of the earthquakes which had happened in the provinces in the Northern part of Luzon in the months of April and May, and deduces from the accounts which he had received concerning the direction of the motions, *that the center of seismic oscillation coincides with a volcano which has been for a long time extinct, situated between Lepanto and Abra in the central mountain chain of Luzon, in latitude* 16° 22′ *and longitude* 127° *East of the observatory of San Fernando* (1) (2).

One would be led to suppose, from the fact the Director begins his observations in this way, that the earthquakes of April and May, as the Director clearly indicates, continued until the beginning of July, and had a connection with those of July 14—25 which we have just been describing. It will be of interest for us to test in some way the existence of this center of seismic oscillation, of this long extinct volcano situated in the central mountain chain, and markad with such certainty by the illustrious director. We have travelled over the districts of Lepanto and Benguet for some days; we have tried to reach the point which he has indicated by its latitude and longitude; we have taken on the spot notes which we will further along set down on the intensity of the phenomena in the neighborhood of the supposed focus; and we expected logically that there it would have been felt with greater intensity than elsewhere in Luzon. Nowhere have we met any-

(1) This geographical position does not correspond to any point of Abra or Lepanto, but rather to a point to the South of the latter, and in the center of the district of Benguet.

(2) *Longitude* 121° *East of Greenwich.*

thing to confirm this hypothesis, neither extinct volcano, nor indications of an ancient or modern volcanic formation. There are only found plutonic formations constituting the great mountain chain, metamorphic formations (schists and slates of various kinds), sedimentary, lower tertiary, or perhaps cretaceous formations, and modern alluviums. We learned that the effects of the earthquakes had not been by far as great as in the provinces in the center of Luzon; and finally upon visiting the point which appears to agree, by its situation between the two districts, with the supposed focus of seismic irradiation, which was the high mountain called Dalá cited in various works, and in some of them as volcanic, we met at 1600 metres above the sea-level with magnificent tertiary limestones, which by their presence protest against the theory of a volcanic origin of this mountain, which by a printer's error Father Faura has placed between Lepanto and Abra while it really is between Lepanto and Benguet. In spite of this negative testimony let us not venture to form an opinon on Father Faura's hypothesis before hearing his statements; let us see whether the data which he has used will not clear up our doubts on the subject. We have conferred with him and he has frankly shown us that in proposing this hypothesis he only considered the reports, more or less exact, which he had received from the provinces of the North, and that with them and a map before him he thought he had found the focus of seismic irradiation, which according to our view does not exist.

We have insisted at some length on this point, because the hypothesis is already laid before the public, and by it an important and still obscure problem of geology is solved or professed to be solved, and the author of this hypothesis is such a respectable gentleman as Father Federic Faura. Our silence would have been construed either as blameworthy forgetfulness or as assent to his opinion.

He proceeds in the résumé to analyze the different figures which were drawn on the seismograph by the pendulum; he then gives some reflections on the various foci of seismic irradiation, on their positions and on the changes which these

foci have undergone from one earthquake to another; and he concludes with the following paragraph, which we transcribe because it condenses the important part of the observations:—

"We will now review, and fix what the figures tell us. In that of the 14th, which is the one which is numbered I in the first plate, we note two centers of seismic irradiation, one in the second quadrant where the earthquake began, and the other in the first quadrant where it ended. On the 18th we again find the two foci just mentioned, but other new ones appear, which drive the pendulum in all imaginable directions, as may be seen in Figure 2, plate 1. The record of the earthquake of the afternoon of the 20th, in which it may be observed that the focus of the second quadrant is working with wonderful violence while the others have disappeared, is given in Fig. 3, plate 2. Now we will examine Figure 4 plate 2 which shows the fearful shock of the night of the 20th; we notice a very great change with regard to the foci of seismic irradiation; the oscillations from East to West, which correspond to the focus which was working before with so much violence, are gradual and of much less intensity; on the contrary, those from N. E. to S. W. show a great force of undulation from these points. Finally let us observe Fig. 5, plate 2, which shows the last important oscillation at daybreak on the 25th; it will be seen that only the focus in the first quadrant now appears working with very slight intensity, the other foci disappearing completely. We will not now try to deduce any consequence of the results thus far pointed out; we have only wished to point them out in order that they may be studied by others for themselves without being influenced by our opinions."

It is much to be regretted that the learned Jesuit, who at the time of the earthquake was always beside his instruments in an observatory perfectly supplied with scientific instruments of all kinds, to whom were immediately sent all the official telegraphic and postal notices on earthquakes from the provinces, in order that with them, with his instruments and with his science he might obtain some result from their study; it is lamentable, we say, that that scientific gentleman left some

days without seeking to deduce the consequences from his observations, only indicating the facts observed in order that investigators who had no instruments, no observatory, no time at those sad moments to devote to scientific speculations, might consider them without being influenced by the opinions of Father Faura.

If, as we believe, and as appears from his own words, he had formed an opinion concerning the phenomenon, although not exact yet with some foundation, he ought to have published it, even though it might have been with the reserve which in this kind of studies, so new and complicated, ought always to be claimed; and in so doing he would have rendered a service to science, which today uses all kinds of observations, however insignificant they may be, to deduce from them some valuable result. The Scientific Commission recently created in Zurich under the direction of the learned Prof. Albert Heim to study earthquakes, begins by recognizing its ignorance on this class of phenomena, and invites all persons interested in science, not only in that nation but in the whole world, to collect and send to the commission facts and opinions, however unimportant they may seem; and it carries its kindness and good intention even to the point of printing and circulating most detailed interrogatories, so that those who wish to contribute to this grand work may do so with greater facility and certainty. If that commission asks aid from the whole world, with what gratitude would they have received the deductions, the result of the studies on the Luzon earthquakes of July, made by Father Faura. For our own part, we must declare freely that we should have had much greater satisfaction in following the opinion of Father Faura if it had convinced us, than in sending out, alone and unguided by Father Faura's theories, our own opinions full as they are of doubts, reserves, and vacillations.

II

General Remarks on the Effects produced.

It is truly wonderful that with such violent shocks in all directions, with such great movements as were experienced

during the three great earthquakes, there remained standing in Manila a single building of rubble masonry. We freely confess that after the earthquake of the 18th we expected to find the town in ruins; and we could not explain the good condition of all or almost all these masonry buildings. They were without apparent injuries; although in very bad repair, their walls falling to pieces, their frames rotten, the partitions broken or tumbled down, yet they were standing and without being notably or even very perceptibly out of line.

We were equally surprised after the shocks of the 20th, especially as the buildings had already been shaken; but the effects were not as great as we all expected they would be, bearing in mind that some of the oscillations had amplitudes greater than 22°, and that the index of the vertical seismograph was moved 34 millimetres, and considering the energy which these motions indicated.

It would be too long a task to describe all the effects of the earthquakes on buildings; and further, as the only object of such a description would be to determine the direction and nature of the motions, which we already know with great certainty from the records of the seismometer in the observatory, we have thought best to omit this description. Those who wish to investigate this subject, can find it given with minute details in the reports made under the Inspectorate General of Public Works.

We shall then limit ourselves to a few general considerations, which may, if we are successful in presenting them, be found useful in reference to future constructions in Manila, with regard to the methods of erecting buildings, as well as to the sites chosen.

In the first place, and as a general rule, it is worthy of notice, that the greater part, if not all, the cracks which have opened in the ground, the upheavals of the surface, and even the depressions which have been observed in some places, have always taken place in the vicinity of rivers, or estuaries (marshes) or the sea. We have confirmed this, not only in Manila, but in various other places in Luzon, and we have always found that this class of phenomena present themselves

in the neighborhood of old watercourses or of those formed by recent inundations, where the sudden shocks produce in the superficial and, so to speak, spongy formations unequal motions, according to the form and nature of the older formation on which they repose; and consequently cause upheavals, figures, depressions and perhaps submersion of portions of the soil. On the banks of the river Pasig and the shores of the marshes in the neighborhood of Manila these effects were to be clearly seen; and it may be set down as a general rule that the buildings situated in the immediate vicinity of these bodies of water suffered much more than those further away. A good example is the suburb San Miguel on the right bank of the Pasig, which is composed mainly of well-built structures, and which suffered much more than other suburbs further from the river, whose buildings were badly built and out of repair. In the Palace of Malacañang, the residence of the governor, situated close to the same river, besides great damages caused by the three great shocks in the old part of the edifice, a fissure two centimetres wide and approximately parallel to the watercourse was formed, causing the fall of a great part of the masonry wall which ran along the boundary-line of this enclosure. That fissure some 40 metres long, although narrow and probably partly filled by the falling in of its sides, could be sounded to a depth of four metres, which indicates that its depth was much greater when it was first formed; it may be safely assumed that it traversed the whole modern fluvial alluvium, and reached the volcanic deposit which forms the basis of almost all the province of Manila and part of Bulacan.

This recent alluvium may be supposed to be more yielding, more impregnated with water, in short, more spongy in the localities now passed through by streams of water than in dry regions, and that in the former places the sudden shocks of the earthquakes produce irregular motions which give rise to fissures. Through these fissures the compressed water which fills the soil seeks to escape, carrying with it decomposing vegetable materials which give to the water a dark color, a nauseous odor, or sometimes a sulphurous one, producing great

alarm on the part of some persons, who imagine that every fissure is the opening of a volcano.

The same effects which we have just described on the Pasig, took place, but on a much greater scale, in the region of the Grande river in the province of Pampanga (Rio Grande de la Pampanga) which extends from Cabanatuan in Nueva Ecija to mount Arayat. In this region, concerning which we shall speak more in detail further on, in certain places there were formed fissures some kilometres long and some metres wide, which converted that locality into a real net through which three months afterwards, though continuous rains had undoubtedly contributed to fill these cracks up, we had great difficulty in travelling, as at every instant we were in danger of falling into the fissures.

Analogous, though less violent, effects were observed in the region of the river Agno, in the province of Pangasinan, in the villages of Bayambang and Alcala, on the river Grande of Tarlac (Rio Grande de Tarlac), in the district of Aguso, and in general on all the rivers of wide beds which traverse alluvial plains; so also on the coast near the mouths of great rivers, as in the villages of Mamban and Atimonan in the province of Tayabas, situated on alluvial formations, where there were fissures near the sea of the same form and identical origin with those above mentioned.

Besides these effects on the ground, against which there is no means of protecting buildings except by removing them as far as possible from the water and building them of light and elastic materials, we ought to consider the effects observed in the buildings themselves, in order to deduce from them if possible the modifications which ought to be introduced in future structures.

The author now enters into a practical consideration of the best forms of constructions followed in this country.

SECTION 2.

Local Observations and Effects.

This section will include the local observations and effects in a great part of the island of Luzon; and for the purpose of

establishing some order in the description, we have divided the island into three zones, that of the North, that of the center, and that of the South, which will correspond to as many chapters; and in a fourth chapter will be given a résumé of all the observations, in order to deduce the extent of the zones of disturbance.

I

Effects observed in the provinces of the North of Luzon.

Pangasinan.

As has already been mentioned, we began our examination of the island of Luzon in the province of Pangasinan, landing at Sual and passing through the villages of Luigayen, Bimaley Dagupan, Mangaldan, San Jacinto, Manasag, Binalonan, San Manuel, Urdaneta, San Carlos, Malasiqui, Bayambang, and Alcalá.

The effects produced generally by the earthquakes of July were not nearly as great or as disastrous in this province as in Manila; not so much because the vibrations were less intense or less numerous, but because the principal masonry buildings, the churches, the parochial houses, the court-houses, and a very few private buildings in the more important village, are covered with galvanized iron or with *nipa*, very few buildings being covered with tiles. Besides, the scarcity of building stone in this flat province where almost all the soil is alluvial has rendered the use of brick obligatory, so that the masonry is much superior to that seen in the central provinces, where generally volcanic stone is used.

From all the reports which we received from the rectors of the parishes and the principal persons in the villages which we passed through, as well as from the official records which were placed at our disposal by the governor of the province, it is evident that of the three great earthquakes only that of the 18th was felt with great intensity, the two of the 20th having been of little importance, and the feeble shocks which before and after those days were felt so frequently in Manila passing unnoticed. Further it is to be remarked, from the effects

noticed in the ground and on buildings, as well as from the reports given by the persons above named, that the intensity of the earthquake of the 18th was less and less from the South-eastern portion of the province towards the North-western portion, so that in the villages situated around the gulf of Lingayen (Sual, Lingayen, Bimaley, Dagupan, etc.) there were only the very slightest injuries to masonry buildings, even those covered with tiles; while in other villages in the interior (San Jacinto, Malasiqui, Bayambang, etc.) the earthquake left very evident marks of its influence, not only in the buildings which were left in ruins, as the churches of San Jacinto and Malasiqui, but also in the ground, where fissures were produced which can be seen today, as in the villages of Mayambang, Alcalá and Asingan.

From this observation it may apparently be deduced that the general direction of the motion was from the second to the fourth quadrant.

Province of la Union.

In this province situated to the North of Pangasinan the earthquakes of July were felt even less than in the latter province; and the same law of decrement of intensity from the South toward the North, or more exactly from S. E. to N. W., was observed. In none of the buildings, which are of a weak sandstone and not of the best workmanship, have there been great injuries. However some of the earthquakes were felt with the same violence as in Manila; in some of the villages, as in Namagpacan in the northern part of the province and near the sea-shore, the shock of the 18th was felt with some intensity, but did not however cause any damage; the others according to the statement of the curate were imperceptible. On the contrary in Balasang, a village further inland, but situated toward the East and near the first foot-hills of the mountain chain, the earthquake of the 18th was felt with great force, and caused more damage to the church and convent than happened to any other buildings on the coast. And the two earthquakes of the 20th were felt here, although but feebly.

This remarkable difference between two villages distant

but a league from each other can not, as we think, be attributed solely to the gradual diminution of the seismic current, for although this is very evident in an extent as great as that of the whole island, it is not natural to suppose so sudden a change in a phenomenon which has such wide extent. The notable circumstance that subterranean noises were heard at the instant of the earthquake in Balasang and not in Namagpacan brings up the question whether in the general commotion there were not produced in the mountains near to Balasang subterranean disturbances which increased the vibrations in that limited district.

We think it useless to detail the effects produced in all the villages of the province, and we confine ourselves to a few of the effects, which can show how the violence of the phenomenon diminished, leaving aside the others which are of no interest in our present investigation.

Balasang. It may be remarked that this village situated, as we have said, a short distance from Namagpacan towards the interior, was the point of all the province where the earthquake of the 18th and some later shocks were felt with the greatest intensity. The convent and church were left in a bad condition with cracks in all the arches over the doors and windows, and some in the walls. The ground on which the convent stood was cracked transversely to the edifice, doubtless on account of the pressure which the vertical motions produced, or perhaps on account of bad foundation.

A house built of boards and stucco which stood near the convent lost its walls, leaving in the front only the cane gutters hanging from the eaves.

Finally, the curate of the village, Father Juan Perez, pointed out to us a remarkable effect, which showed the intensity of the shocks. A small tree, called in the country Bag-bag, five metres high, with quite a stout trunk and very few branches, fell during the earthquake tearing out its roots; a remarkable effect, knowing which we can not explain how a single building in the village remained standing. Really we should not have believed such a thing possible, if we had not the statement of such a respectable person.

District of Benguet.

The diminution of intensity from the interior towards the coast, which we had just observed, led us to visit this district, situated on the East of La Union. We went from Aringay, and passing through Galiano by a road which at some points reaches a height of 1550 metres above the sea, we arrived at La Trinidad, the capital and only Christian village of this district. We were further induced to make this excursion by a story which we had heard, and which was founded on an old chronicle of the order of the Augustines, as, according to this story, at the beginning of the last century quite a large number of cottages, situated to the East of Aringay and occupied by the natives, had disappeared in a great earthquake which produced the submersion of an extensive tract of land.

According to the reports which we received from the commandant of this district, Señor Oraa, and a few which we were able to collect, we were able to conclude that on the 18th of July there were felt not only the earthquake at mid-day, but also two others a short time afterwards; the third which occurred two hours after the first being accompanied by a great subterranean noise. The shocks of the two following days were of little intensity, including those of the 20th, which could not be distinguished by their force from the others. We did not obtain any information from the officers of the Civil Guard, the only Europeans living there, concerning accidents caused by earthquakes; and attempting to verify the story which we have mentioned above, we were unable to gain any facts. Doubtless the topography of the beautiful plain in which La Trinidad is situated might give some reason for conjectures on the subject. A level circular plain about four kilometres in diameter is surrounded on all sides by hills whose height does not exceed 130 metres. In the interior of this plain is a lake whose only outlet is through a fissure toward the north-east, and this outlet perhaps gives rise to the river which empties at Bauang (Union). Looking down on this circular depression from the last heights (1550 metres altitude) which are passed in reaching La Trinidad, the valley

presents all the appearance of an old crater and it was our first impression that it was one. We, on the following day, examined some of the hills which surround the valley, thinking to find in them the rocks which would confirm or modify our suspicions. Not a single volcanic rock did we find; on the countrary we were surprised to see calcareous rocks with a great abundance of fossils (madrepores and some bivalves) which could not be older than the tertiary period. How shall we explain then this great depression, so regular and flat, whose soil is composed of alluvium washed down from the surronding hills, and is consequently posterior to them. We are far from suggesting that this is the origin of the story cited, because the time passed is not sufficient for the tradition to die out even among savage races, and because much less is the time sufficient in a geological point of view for all vestiges of such a phenomenon to have disappeared, or for so thick a deposit of alluvium as now covers and converts the plain into a fertile prairie to have formed.

But it occurs to us that perhaps the chronicle is not without foundation, but that an analogous phenomenon independently of any volcanic action may have happened in some other locality in the district, which unfortunately is very little known, if not in La Trinidad; and that by subterranean commotions, produced perhaps by the earthquakes whose action reaches the surface of the ground, a circular valley was formed, the first effect being to inundate the country until the water by its pressure and chemical action made an outlet for itself, leaving dry at the end of some centuries beautiful prairies like the one we are now considering.

We did not think the foregoing observations out of place because they are somewhat connected with our work, and because this district of Benguet by its situation, its delightful climate with a temperature which varies annually between 8 and 20 degrees centigrade, and from many other circumstances, is a very interesting locality in the interior of Luzon, which at no distant day will attract the attention of the government.

NORTH AND SOUTH YLOCOS.

As these two provinces are topographically the same and form a continuous zone from South to North, and as the phenomena observed in both of them are very few and of little interest, we shall consider them together. The provinces are bounded on the West by the China Sea, and on the East by the central cordillera, which separates them from Lepanto and Abra. Throughout the whole territory considered, the earthquakes of July were but feebly felt, and did not produce any considerable effect either in the buildings or the ground. Here, as in the other provinces which we have studied, the diminution in intensity from South to North is to be noticed; and this is confirmed not only on the coast, but also in the interior of the island, since, according to all the reports received concerning the provinces of Cagayan and Ysabela at the time of the earthquake from various residents, only the earthquake of the 18th was felt, and this, although it lasted quite a time, did not cause any injury to the very few masonry buildings which exist in these provinces. As there were no effects to examine in the last named provinces, we did not visit them, saving thus the time which we required in the provinces to the South.

From Tagudin, the first village in the Southern part of South Ylocos, up to Pasuquin near Cape Bojeador in North Ylocos, we could not observe in any of the intermediate villages that there had been any seismic action which merited attention; and in all these places we were assured by the curates that the shock of the 18th was felt, followed for some days by very slight shocks which in many cases were not perceived. From the village of Cabugao towards the north we began to notice injuries to the buildings, which attracted our attention the more because it in a certain measure destroyed the law of decrement which we had before observed; but we discovered that these injuries were not due to the earthquakes of July, but to one which happened in December 1879, which was stronger here than the July ones, and which must have acted over a very small area, as it was felt only in the villages of

North Ylocos. It should be noted that the effects which we observed in buildings indicated clearly that the law of decrement in the earthquake of 1879 was the reverse of that in the July earthquakes, that is from North to South.

Districts of Lepanto.

Although our journey to Benguet had shown us that no notable phenomenon had occurred in central Luzon, if it were not a slight increase of intensity in the earthquakes compared with the Western coast, we resolved nevertheless to make a new excursion to Lepanto; not so much to widen our field of observations, as to test a theory published by Father Faura concerning the existence of an extinct volcano in this district, which was said to be the probable center of seismic irradiation. We have published our opinion and our observations on the supposed focus elsewhere, and we have nothing to add now; but we have promised to describe the principal seismic effects in this district and we will fulfil our promise.

Our itinerary was as follows:—We left Candon and going through Salcedo passed over the mountain Tila to Angaqui situated on tne left bank of the Abra in its high part. Then we passed over to Cervantes, Mancayan, Tubic, and Mount Datá, returning to Cervantes to go to Cagayan, the principal place of the district. Thence we descended again to the coast, passing the mountains at a place called Tabalina; and went through Tiagan to Santa Maria a town on the coast to the north of Candon.

In none of the places named, which were composed principally of small huts built of wood, cane, or cogon, could we see any effects of the earthquakes, and the reports which we could collect from the natives agree in saying that the earthquake of the 18th alone was of any importance; the remainder, which were felt until the 20th, were very small and scarcely perceptible. We are able to estimate the relative intensities of the shocks from the high dry stone walls which the natives erect to support their little tracts of cultivated land in the mountains; and the perfect state in which we found these walls indicated that the motions of the earthquakes had

not been violent enough even to tumble down these weak constructions.

At the metallurgical works at Mancayan there is, besides other structures, a furnace for refining copper with quite a high chimney, which was not injured at all by the earthquakes. The mines at this place have been worked for a long time and in a most economical manner so far as the supporting walls are concerned, and in not a single case did the walls fall down.

Only on the Southern side of Mount Datá were we able to find any considerable marks of seismic action on the ground; and these were due not only to the intensity of the shock, but also to the special configuration of the ground. On the banks of the deep stream, which from its direction appears to be an affluent of the river Suyuc, there were places where the earth had fallen in, where there appeared to be numerous cracks on both banks, though they had but little length.

An analogous phenomenon, but of less extent, happened on the North-east slope of the mountain in the neighborhood of Cayan; we will not describe it, as it offers nothing new.

Zambales.

On the return from the provinces of the North, our assistant Don Enrique d'Almonte (the writer having been taken sick) passed from Sual to the province of Zambales, and in some of the villages gathered information, from which it appears that the earthquakes, except perhaps that of the 18th, were but little felt, and caused neither damage to buildings nor cracks in the ground. We will not give the details of the very slight effects which were observed; we will only add that the mail steamer "Elus" was sailing along this coast during the afternoon and night of the 20th, and that on board of her none of the fearful shocks felt at Manila were noticed.

II

Effects observed in the Central Provinces of Luzon.

Tarlac, Pampanga and Bataan.

The tract of country which extends Southward parallel to the mountain chain of Zámbales from the limits Pangasinan,

including the three provinces which we are about to study, was but little influenced by the earthquakes of July; however it may be observed that their energy was greater in the more distant points, those just to the East of the mountains of Zambales, than in points nearer to Manila, as should be the case according to the law observed in the provinces in the North. In the province of Bataan, which is the most Western one and includes both slopes of Mount Mariveles, the Southern end of the Zambales chain, the earthquake of the 18th had but little intensity, and the others were just perceptible, in no case causing damage to buildings in this province; while in Pampanga and Tarlac the effects were much greater in the villages distant from the Zambales monntains.

In Camiling, Capas, Mabalacat, Angeles, Bacolor, and Guagua, all situated on a North and South line near the mountains, we did not observe any great marks of the earthquakes, either in the buildings or the ground; in other places like Tarlac, Arayat, Santa Ana, Mexico and Macabebe situated further to the East, the effects in the ground and buildings were much greater; for example the church at Mexico was left in such a condition that it was necessary to pull it down, and in Macabebe one of the towers of the church was tumbled into ruins.

Nueva Ecija.

The effects of the earthquake of the 18th of July, the only one which was very heavy in this province, were truly imposing in all the region included between Cabiao and Cabanatuan on one side, and on the other side the river which rising in the mountains on the East of the province and passing through Bongabong, Cabanatuan and San Ysidro finally joins near Mount Arayat with the Rio Chico de la Pampanga forming the Rio Grande de la Pampanga. To the violence of the shocks, there was here joined the circumstance that the soil is of very recent formation consisting of the modern alluvial deposits of the Rio Grande; and these two circumstances together caused great and unequal depressions and numerous fissures, from which water and sand in great quanti-

ties were discharged, inundating extensive tracts of land and rendering many fields valueless.

The general direction of the great fissures was from East-north-east to West-south-west; and the spaces between these fissures were divided in every direction by others which were narrower (from 10 to 50 centimetres wide) but very deep. Three months after they were formed, although there had been heavy rain storms meanwhile, the fissures were not filled up; and when we visited them many still were of very great depth. Some of the great fissures run in the direction already given from the district of Sapan to Buliran, passing through the village of San Antonio, and having a breadth which reaches in some places 10 metres.

Between the river and village of San Antonio there were two fissures which were so wide as to appear like sections of the earth; the one nearest the river had a breadth of 6 metres, and the other, 200 metres away from the first, a breadth of 10 metres, and the ground between the two sank two and a half metres.

At some points near the bank of the river so numerous were the cracks that the ground presented the appearance of a pavement, the stones of which had been thrown out of position and level. At other places, besides the fissures, there were notable changes of level, so that the surface of the ground was broken into steps as in the case of a farm in the district called Delincuente near the village of San Antonio, where in a sugar-cane field which was originally flat, the surface was so disturbed that in some cases the top of one row of plants fully grown was on a level with the roots of the next, and of the 10 hectares of the field 8 remained valueless.

The width of some of the fissures was so great that in one of them a carabao (boat) disappeared; and we could see full grown trees (*magnifera indica*) hanging by their branches on the edges of the fissures. We might give great numbers of this kind of accidents, but it would only uselessly enlarge our too diffuse account, without adding any facts which can not easily be imagined; such as the partial destruction of a few houses of cane and "nipa," when two or more of the supporting posts happened to fall into a fissure.

Happily for the unfortunate people, the earthquake happened at an hour (noon) when they were necessarily in their houses, thus avoiding the many accidents and injuries, which would have occurred had they been working in the fields. A single accident of this kind was recorded, which happened on the farm of a man named Juan Fernandez. Three children were playing together when the earthquake began; they were frightened and ran towards the house, which two of them reached; but the third fell into a fissure which opened under his feet and immediately closed again. After the first instants of anguish, excavations were commenced on the spot pointed out by his little companions, and after several attempts his body was found at a little depth, completely crushed.

The vertical shocks were so sudden and so violent that the effects were much greater than in any other part of Luzon which we have visited. We will only mention the damages which masonry buildings suffered: the church of San Ysidro, which although without a roof fell so quickly as to bury in its ruins a child who was passing near it; the church of San Antonio, the front of which fell down, and the tower of which, built of small rounded stones laid in cement, the best kind of masonry perhaps, was thrown down even to the base; and many other masonry buildings which were more or less damaged. We think it will be of interest to describe two cases more in detail; the first is that of a deep well, having a lining built of the best masonry with a foundation of concrete, in the suburb of Sampang near a distillery which was supplied from it. The violence of the shocks lowered the ground on which the distillery stood about one metre, without greatly disturbing the machinery in it; while the well, which was full of water, was left dry and partly filled with sand, and the masonry curbing, either on account of its different density with reference to the soil, or for some other cause which it is difficult to discover, was left projecting some distance above the surface of the ground. The second case, which seems to us the most notable of any observed in the whole extent of territory affected by the earthquake, was that of the church in the little village of Jaen, this edifice had been recently constructed, and con-

sisted of great upright timbers 14 varas high, 2 varas of this length being sunk into the ground, united at the tops by joists; and on this framework a light roof of wood, cane and "nipa". The building was 60 varas long and 18 wide, and the lateral partitions were of nipa. This structure which would be considered extremely strong against earthquakes, fell to the ground in a most unexpected way. It was thrown vertically to such a height that the upright posts were drawn out of their beds in the ground with scarcely any injury, and then the whole building fell together. A single one of the uprights, which was more strongly attached to the foundation than the others, was not drawn out of the ground, and although it had a diameter of 40 centimetres, it was broken off like a cane at its base, a few fragments of the building remaining attached to the fibres which were not torn away.

In 1871 we inspected for the same purpose some houses in Cottabato, and in 1879 others in a village near to Surigao; these houses were built of wood and nipa and had been thrown down by earthquakes, but they had fallen because the posts by rocking in all directions had opened the framework at the top until the inclination of the timbers was so great that the building fell by its own weight. It is impossible to invent a method of building which will be proof against shocks which throw structures two varas high, and draw the posts out of their resting-places in the ground without greatly disturbing the soil. From facts procured on the spot, we have succeeded in restoring the building as it was at the instant of its fall, in order that a clearer idea may be formed of the wonderful power of the earthquake.

In the mountains East of the province, in the jurisdiction of Bongabon, there were cases in which rocks on the sides of chasms were thrown down, but we were unable to examine them because during our stay the roads were impassible. We will say however on the word of the Curate of San Ysidro, that in the chasm of Lupingan, the banks formed of hanging rocks were thrown down in to the bed of a stream, stopping the water for two days, at the end of which time the water, having risen and its pressure being greatly increased, forced its way through

and caused a sudden inundation to the agreeable surprise of the people of the region who were sorrow-stricken at the sight of the dry river-bed.

Bulacan.

This province like that of Nueva Ecija is traversed by a great river, which rising in the mountains which separate Bulacan and the district of La Infanta passes from East to West and runs into the Rio Grande de la Pampanga, which empties by numerous mouths into the bay of Manila. In spite of the similarity of topography of these two provinces, and although the intensity of the earthquakes was about the same in both, yet the region of the Bulacan river did not present the disastrous effects which were described in speaking of the region of the river of Nueva Ecija. The difference arose, we believe, from the difference of the geological characters of the soil; in the latter the soil is composed, as we have said, of thick layers of modern alluvium, which are without consistency, and hence subject to disturbances of the surface, and consequently to the fissures which we have described; on the contrary in Bulacan the soil is composed of very deep strata of a volcanic stone which is strong and elastic, in which changes of level, fissures, and land-slides are impossible.

This great volcanic formation, of whose origin and wide extent we shall at some future time speak more fully than is here possible, when it was formed, raised the level of this province, leaving the streams running in deep channels as may to-day be observed, and crowding in the banks of the river, which are very steep throughout the volcanic formation. To this last fact it is to be attributed that this province is so free from inundations, and that the recent alluvium posterior to the volcanic formation is only of a very insignificant thickness and very uniform, as it has been for long periods of time free from the action of the water which is usually at a level below the alluvium. As a confirmation of this hypothesis we can cite the low and littoral region of this province, whose surface is almost down to the sea level, and which is composed of recent alluvia in which there have been observed phenomena

analogous to those of Nueva Ecija, that is, fissures and elevations and depressions of the surface. In the low region just mentioned is the town of Hagonoy, where the earthquakes were felt with extreme violence, and gave rise to depressions and inundations which caused the destruction of houses built of wood and "nipa," and to the opening of fissures two metres wide from which poured forth water and sand in abundance.

We have then in this province two distinct regions in which to study the action of earthquakes; the region of the volcanic formation, which includes the central portion of the province, and the low and littoral portion. In both regions the damages to masonry buildings have been great, perhaps somewhat greater in the low towns than in the high ones; thus, for example, the church and the elegant mo lern tower of the capital town were destroyed completely, while in Balinag, San Rafael, Angat, and other places on the high land, all the buildings remained standing, although somewhat injured.

In the high region structures in cities suffered, while the ground and structures in the country remained intact; while in the low region structures both in the city and country have been considerably damaged. Neither in this province nor in the others which we have studied were the earthquakes of the afternoon and night of the 20th felt with great violence, although in Manila which is very near they were extremely violent. It is to be noted that the intensity in the different towns of Bulacan was inversely proportioned to the distance from Manila.

After these general remarks on the effects observed in this province, we do not consider it necessary to give details on the different towns which we have travelled through, as they teach nothing new, only confirming the general law which we have given as to intensities and directions of movements, to which there is not a single exception in this province. We will cite a single geological phenomenon which may almost always be seen at times of great earthquakes. There is in a suburb of the village of San Miguel de Mayumo, called Sibul, a large spring; the water is charged with sulphur and iron; and this spring has of late years acquired importance, not only on account of

its medicinal properties, but on account of the beauty of its situation. The spring pours out from under a layer of limestone, and has formed around the orifice a little basin about a metre deep with a corresponding outlet. At the time of the earthquake, this spring completely dried up and it was only after some hours, which had been probably necessary to overcome the obstacles which were thrown down by subterranean disturbances, that the water, which was much more turbid than usual, returned.

Province of Manila.

Although this province is of very small area, it presents points of observation where the intensity of the earthquakes was very different. The earthquakes of the 18th and 20th of July were everywhere very strongly felt; but, comparing carefully the effects experienced in the different towns of the province, it can be divided into two zones which were differently affected; one from the Pasig river toward the North, in which the shock of the 18th produced all or the greater part of the damages, which were but very little increased by the shock of the 20th; the other from the river Pasig toward the South, in which the first earthquake having produced the same effects as in the remainder of the province, the two shocks of the 20th considerably added to the damage, and caused others besides, throwing down structures which had resisted the first shock. We do not seek to carry our theory so far as to consider the Pasig as the mathematical dividing line of the two zones; for this would be thought by many to be a scientific refinement, a mathematical nicety, which we ought to avoid when treating of nature, which in its grand march is not accustomed to submit itself to the petty and too frequently unvaried rigor of science. But it is really worthy of observation, even though it be accidental, that the villages situated on the left bank of the Pasig were damaged much more in the earthquakes of the 20th than those on the right bank. In Manila even, with numerous buildings on both banks of the river, it was noticed that the large structures (churches and towers) suffered more on the left bank than on the right; thus the towers of the

cathedral and of San Agustin, and the cupolas of San Francisco and Recoletos were thrown down almost completely on the 20th; while in the suburbs on the right bank all remained standing without any important damage, the towers of Santa Cruz, Quiapo, Binondo and San Sebastian, all high and of no better construction than those in Manila.

With regard to the other villages in the province, it was observed that in those to the North of the Pasig river, such as Malabon, Navotas, Caloocan, Mariquina, Cainta, and even Pasig on the bank of the river, the destruction was not complete except in the case of masonry buildings in a more or less ruinous condition; while in those to the South of that river, as Paco, Santa Ana, Guadalupe, Pateros, Parañaque, Las Pinas, etc., the damages were more important, in some cases amounting to complete destruction, as in the solid sanctuary of Guadalupe, an ancient structure which had withstood the shocks of the last three centuries without injury, and which, having remained standing through the earthquake of the 18th, was completely destroyed by the falling of its arched roof of masonry on the 20th.

Province of La Laguna and District of Morong.

Let us group these two provinces together, as they include the whole perimeter of the great lake Bay, in which the earthquakes of July present such variations that their study is very complicated, and it is very difficult to deduce general consequences which give a more or less exact idea of the phenomena during the three days, the 14th, 18th, and 20th of July, in which they manifested themselves.

We observe, in the first place, that while the first earthquake of the series, that of the night of the 14th, left no traces of its action in the localities which we have so far studied, and would have had no importance had it not been followed by other greater ones, in the region which we are about to investigate at some points it had a much greater intensity and a much longer duration, and caused considerable damage.

Passing around the lake from Taguig towards the South following the West coast, all the reports which we obtained and the effects which we observed demonstrated that the first earthquake had had no importance in Muntinlupa, Tunasan, Biñan and other places as far as Santa Cruz. In the last place it could be seen that the effects produced by it were much greater than had been observed up to that point; for example, the fall of brick partition walls, and numerous cracks in stone walls of coursed masonry.

In the other towns on the East coast as Longos, Paete, Panguil, Siniloan, etc. and in the corresponding ones in the district of Morong as far as Pililla, we obtained reports of that earthquake, and we were shown marks of seismic action which revealed a greater intensity even than in Santa Cruz; in the village of Pililla the force was so great as to open wide cracks in the church and tower, and throw down one of the few masonry houses which exist in this place. Leaving this village toward the West, the intensity of that earthquake seems to have been constantly less and less until we reach the province of Manila, in which we have already described the phenomena.

The earthquake of the 18th was felt very heavily in both provinces; it is to be noted however that on the Western coast from Taguig to Bay the intensity was somewhat less than on the opposite side of the lake. Thus, the towns Biñan, with many masonry structures, Santa Rosa, Calamba and Los Baños felt the earthquake without any damage; while in the towns on the Eastern coast from Santa Cruz to Santa Maria the masonry structures were mostly laid in ruins.

The earthquake of the 20th, on the contrary, acted with greater violence on the Western coast than in the other parts of the two provinces, and had in some villages greater intensity but less duration than that of the 18th. In confirmation of this statement we will give the following well-known fact. As soon as the people of Biñan knew that Santa Cruz, the capital of the province, had been destroyed by the earthquake of the 18th, while the buildings in their town had escaped injury, they loaded a number of boats with materials and men and went to aid the people of the capital. When they were

returning on the 20th and were about to run into their own port, the earthquake of 3 P.M. took place, and was felt in the boats with extraordinary violence; and when they landed they found their principal buildings demolished. The earthquake which occurred that night finished the work of destruction. We had occasion to make another noteworthy observation in travelling along the Southern coast of the lake, in the villages of Calamba, Los Baños and Bay, situated almost on the slope of the great volcanic mountain called Maquiling. In these three villages so near to the volcano whose influence in the earthquake had been so much exaggerated in Manila, we were agreeably surprised to see only the slightest damages compared with the localities visited before and after this small volcanic region.

The observation of this reduction of intensity led us to believe that the great volcanic mass of Maquiling, the first of the chain of mountains which separate this province from Batangas and Tayabas, served as a barrier to the seismic vibrations, and reduced their intensity, which according to what was observed later was very much less in the Southern provinces.

District of La Infanta.

Three days journey from the village of Siniluan in the province of La Laguna through high and wild mountains, brought us to Binangonan de Lampon, the only village in this province on the island of Luzon. The island of Polillo, containing a village of the same name, is a part of this district.

From the reports which we were able to obtain and the effects observed, we conclude that the earthquakes were extremely severe in this locality, although not so severe as was represented by the public press of Manila, which derived its information from some natives from the Pacific coast through intelligent and well-meaning persons in the province of Laguna.

A certain journal went so far as to suppose that a volcano had appeared on the Pacific coast, and spoke of the formation of new mountains and the disappearance of old ones, of great gaseous and liquid discharges, of a great number of boats cast

up on the shores to a great height above the sea, and even of the disappearance of hundreds of human beings. The greater part of these statements were false and the remainder exaggerated as we shall see.

At about the same time as in Manila in the night of July 14th occurred the first earthquake, which was much more intense here than in Manila. In fact the people of Binangonan assert that this earthquake was the most severe one felt since 1863. Before 9 o'clock on the morning of the 15th the shock was repeated nine times. During the 15th, 16th, 17th, and 18th of the month so frequent were the repetitions that, as many people have assured us, not an hour passed without a shock, and the greater part of them were preceeded by subterranean noises.

A little after midday on the 18th the great earthquake happened, which caused all the injury to buildings and all the disturbances to the ground, of which we shall speak hereafter.

From this time the ground was still until the 20th, when four more shocks were felt during the afternoon and night; it was impossible for us to ascertain the exact times of the earthquakes, but it is reasonable to suppose that they were the same as in Manila. The intensity of the shocks of the 20th was by common report very much less than that of the shock of the 18th.

On the following days slight shocks were frequently felt, but they grew weaker and finally ceased. The governor of the district informed us that in the island of Polillo only the earthquake of the 18th was felt, and that it only caused a very little damage to the church. We were not able to visit the island because at the season of our arrival at La Infanta (22d of December) it is impossible to make the passage from any point without great danger of shipwreck.

The effects produced in the buildings of Binangonan by the earthquake of the 18th were the following:—The church, the tower and the convent, the only masonry buildings in the village, which we were informed were not in good condition, fell to the ground. The church had walls of plaster and a roof of nipa. The tower was all built of plaster, and the convent was built of plaster with a tile roof. The destruction

was complete, especially of the tower, whose foundations were so moved as to disturb the ground which surrounded them.

The government house, the court-house, the barracks, all built of wood and nipa, were so badly injured as to be uninhabitable, and they were so much inclined that the latter finally fell down. More than two hundred houses built of wood and nipa were ruined by the great disturbances of the surface of the ground; some fell down leaving the vertical posts standing loosely in their beds, which had been enlarged by the oscillations.

The disturbances of the ground were, so far as we could see, small in the neighborhood of the village; but they were very considerable at two points on the shore of Puerto Real de Lampon, and in the mountains which separate this district from that of Morong and the province of Bulacan. Close by the village there were only a few fissures of little length near to a stream called Sapa, which runs in a deep bed through a meadow on the North-eastern side of the town, and a little more than a kilometre distant from it. The hanging clay banks of this stream fell down in several places dragging with them the vegetation; and in one place where the bed was very narrow (scarcely two metres wide) the caving-in obstructed the current so that the meadow was partly inundated for a few hours, until the obstruction was washed away.

The other place was about half-an-hour's journey in a South-westerly direction from the town; here fissures were formed of a greater length than those just mentioned, but of very small width, which poured out water and mud. The same thing happened on the shore of Santa Monica and in some other places around the town, but in all these cases the phenomena were on so small a scale as to be hardly worth mention.

In the mountains of the dividing chain of the island, on the West and North-west of Binangonan the effects were very important, producing numerous and great land slides on the steep Eastern slope, which were formerly covered by thick vegetation, and leaving great tracts completely bare. Five months afterwards although the vegetation is very vigorous,

we could count more than sixty of these bare places in the single mountain called Binnan at about six leagues to the North-west of Binangonan. The few inhabitants in the mountains (for the most part natives, negritos,) hurried down to the plains in all haste, terrified at phenomena which made such frightful noises and made the earth vibrate so continuously.

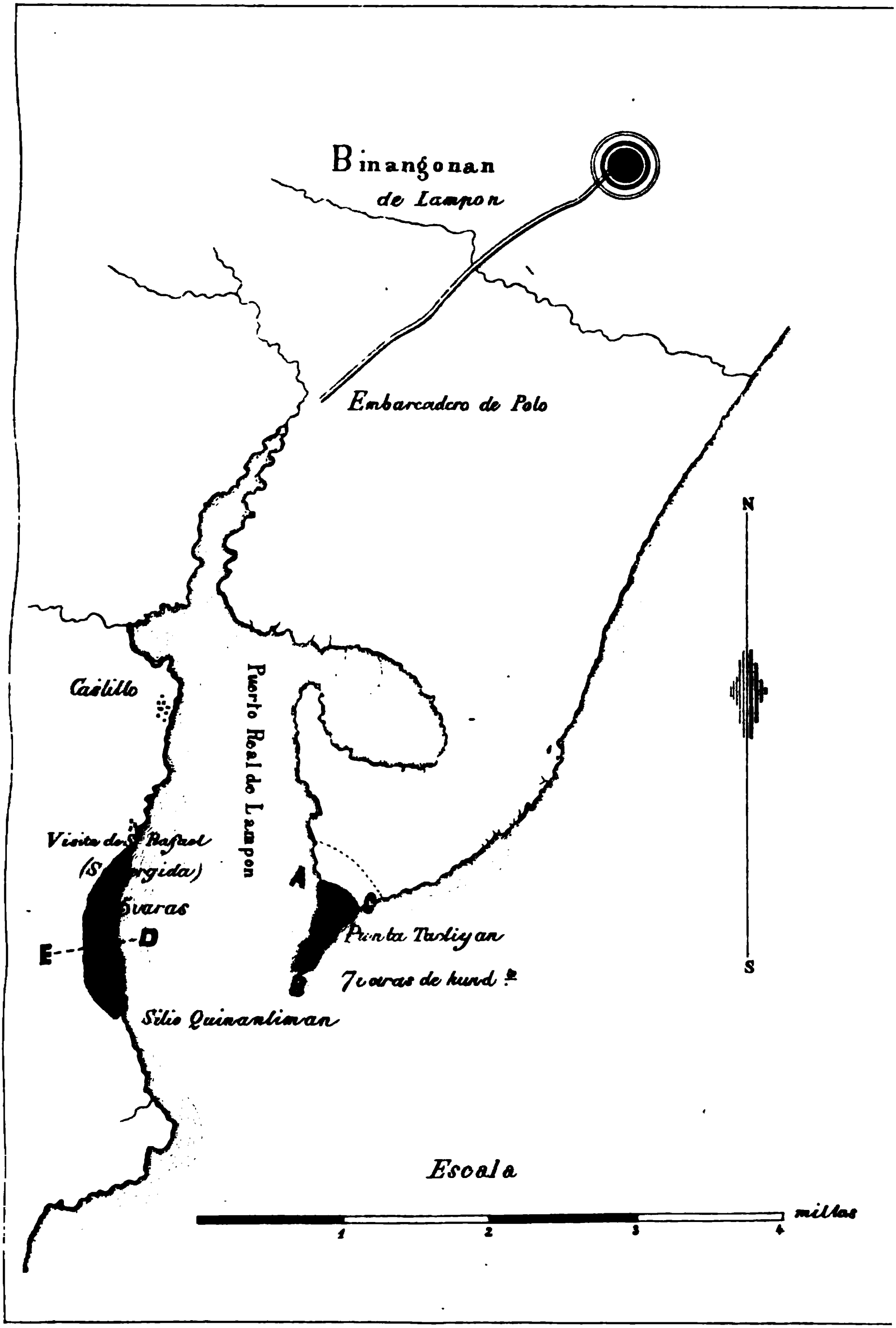
On the coast of the Puerto Real de Lampon, four miles (Spanish) from Binangonan, there are important depressions, one at Point Tacligan and another at a place called Quinanliman. The sketch given herewith shows exactly the situation of these two places.

At Point Tacligan the depression of the land increased from A and C towards B; at the last point, where formerly the land was some decimetres above the surface of the water, the water was six metres deep; while at A and C, the ground was lowered only so much that the vegetation, which was very thick at this place, was killed by the action of the salt water on its roots. At B the dead tops of the submerged trees were visible. It appears as if the whole tongue of land had revolved about an axis approximately parallel to the line A C.

At Quinanliman the depression had a wide extent, but was very irregular in depth: the greatest depth was four metres at the centre line D E of the submerged surface; and from this line in both directions the depth gradually diminished.

A suburb called San Rafael had been formed in this locality a short time before the earthquakes, to take advantage of the good farming land. This suburb was submerged the 18th of July, and was abandoned without loss of life. It is probably this incident which gave rise to the story in Manila that hundreds of human beings had disappeared.

With regard to the story of the boats which had been cast up on the shore to a great height above the sea, we could not find any confirmation of it; even the fishermen in Puerto Real were astonished when we told them of it. The only accident which offers any explanation of such exaggeration is that some small boats which had been out in the estuary which opens into this port, were thrown by the inundating waters up



Binangonan
de Lampon
Embarcadero de Polo
N
S
Castillo
Puerto Real de Lampon
Visita de S. Rafael
A
C
Punta Tadiyan
7 varas de fund.
E
D
Silio Quinanliman
Escala
1
2
3
4
millas

into the mangrove thickets which line the shores of the estuary, and were left dry when the water returned to its level.

PROVINCE OF CAVITE.

The effects produced in this province were almost as great as those in the contiguous parts of the province of Manila. The shocks were felt with equal violence and in equal number, although it was observed that the intensity was gradually less from North-east to North-west.

We will not enter into details concerning the action of the earthquakes; it will be sufficient to say that some buildings were more or less injured, while the ground showed no marks of violence except some small cracks at points near the shore, as at Cañacao, where several were opened which poured out water and sand.

III

Effects observed in the Southern Provinces.

BATANGAS.

It was with great anticipations that we went to examine this typical volcanic province, thinking to find more notable marks of the earthquakes of July in its soil than in any of the provinces already travelled over. The reports, sometimes terrifying and sometimes reassuring, which were received in Manila concerning the volcano of Taal and mount Maquiling, which were then considered the arbiters of our fate; the telegrams, as laconic as alarming, which represented these mountains to be first in full eruption and then perfectly quiet; those urgent warnings, advising the precautions to be observed on account of the suspicious state of the volcano; all these reports, these prophetic warnings, which were in no way confirmed, excited our desire to visit this province, which we expected to find completely disorganized by the earthquakes of July. What was our surprise to find that if those volcanoes had had any influence on the effect of the earthquakes, it was a markedly beneficial one.

Neither the crater of Taal nor the boiling springs on the South-western side of Maquiling, which we examined carefully

showed any marks of recent change, much less of such cataclysms as young and enthusiastic imaginations had thought they saw. According to the reports which we obtained in the locality, when people had become somewhat reassured, it seems that not only did no new volcano appear, (a supposition which might have arisen from one of the beautiful tropical sunsets or from mistaking some other peak) but that the old ones showed no abnormal activity, indeed not as much as they often do when unaccompanied with earthquakes.

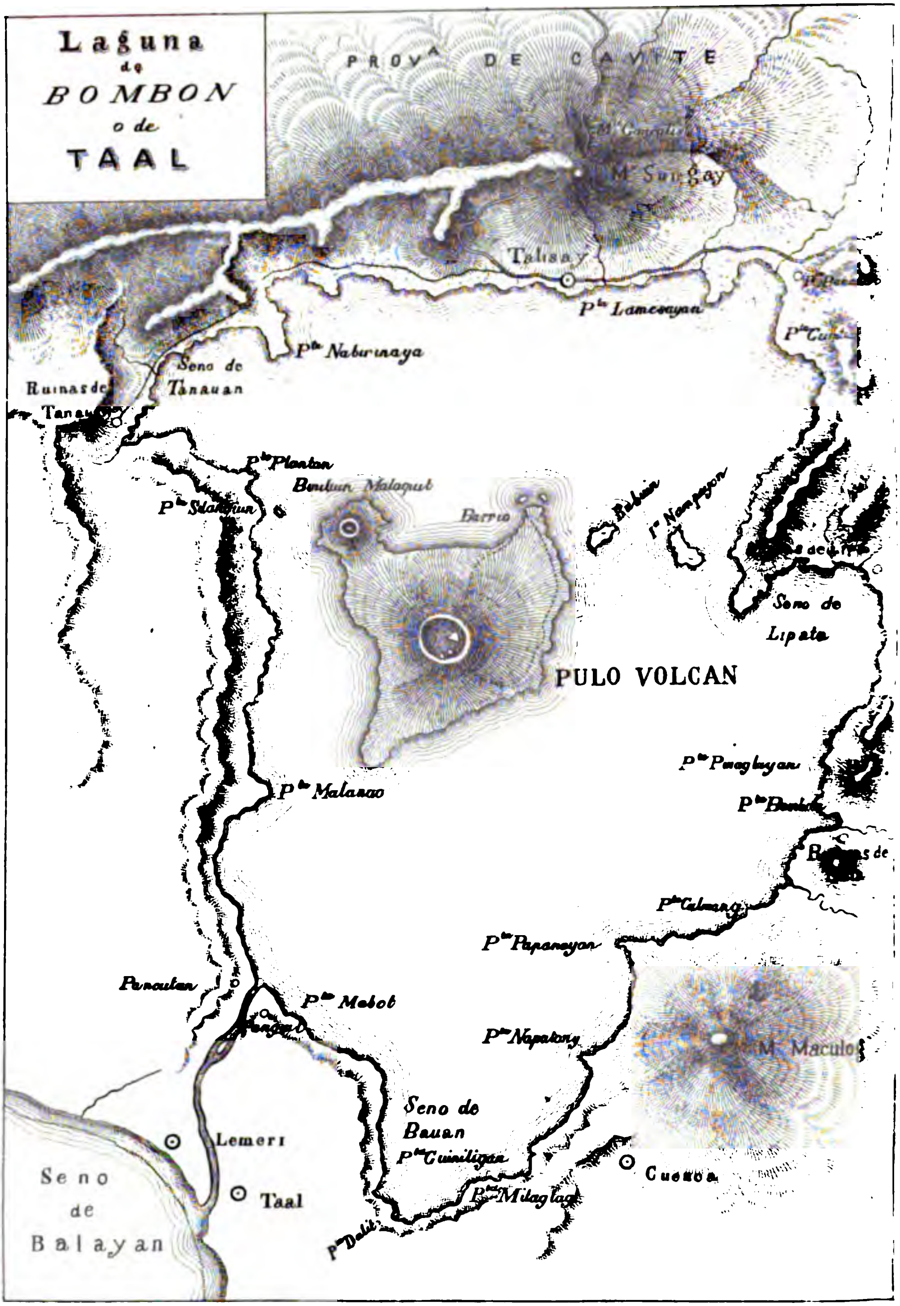
We entered this province from the town of Calamba in La Laguna, and passed successively through the towns of Santo Tomas, Tananang, and Talisay, Taal, Banang, Batangas, San Jose, and Lipa; returning to Santo Tomas, we took the road to San Pablo and afterwards proceeded to Tayabas. We stopped in Santo Tomas especially to investigate the hot springs of Mount Maquiling, and again in Talisay as the nearest point from which to visit the little island which was formed by the volcano of Taal in the middle of lake Bombong.

In none of the villages passed through did we observe any effects of the earthquakes, either in the ground or the buildings. In Santo Tomas, the village nearest to the province of La Laguna, the church was considerably damaged, but this was due to faulty construction rather than to the action of the earthquake; as the convent next to the church, which was built of masonry and covered with tiles was so little injured that it was, without repairs, continually occupied. In the town of Lipa, where there were numerous edifices of masonry covered with tiles, and higher than we have seen elsewhere in the Philippines*, there was not the slightest injury; even in the five-story tower of the church there was not a visible crack.

The same earthquakes were felt as in Manila; but the greater part of the reports received agree in assigning the greatest importance to the shock of the 18th, and placing the anterior and posterior ones much lower in the scale of intensity.

The statements which we could make concerning the effects in this locality would be mainly negative; it will suffice

* There are some buildings having a ground floor and three other stories, all covered with a tile roof


Laguna
de
BOMBON
o de
TAAL
PROVA DE CAVITE
Mt Sungay
Talisay
Pta Lamesayan
Pta Naburnaya
Seno de
Tanauan
Ruinas de
Tanauan
Pta Plantan
Pta Sitangiun
Barrio
PULO VOLCAN
Seno de
Lipata
Pta Malaxao
Pta Calmang
Pta Papaneyan
Panautan
Pta Mabol
Pta Napalong
M. Maculot
Seno de
Bauan
Pta Guiniligan
Pta Milaglag
Pta Dalit
Cuenca
Lemeri
Taal
Seno
de
Balayan

to say that, with the exception of the village of Santo Tomas, none of the churches of this province, including the very high one of Taal, nor of the great masonry structures which are numerous in many of the villages, suffered noteworthy damage, the small damage experienced amounting to a few cracks which did not affect the stability.

Here we ought to terminate what we have to say concerning the earthquakes of July in this province; but considering that, among the theories which have been advanced by eminent men in all times relating to such phenomena, there is one theory which attributes them to volcanic action, we can not let such an inviting opportunity pass by to study an active volcano in the midst of a zone lately disturbed by heavy earthquakes, as well as to say a few words on that igneous center and the scientific paper which was intended to show a connection between this volcano and past seismic events.

The sketch herewith shows the situation in the lake of Bombong of the island called Puló Volcan in whose top there is now a crater, as well as the situation of the other small islands in the same lake, all of which are volcanic and have been active in historic times. The islands of Bubuin and Nampayon appeared in 1716, forming then a single island, and the principal crater was then in an island known as Subugnapuls which disappeared in the eruption of that year, although its base may still be seen near the island Puló Volcan.

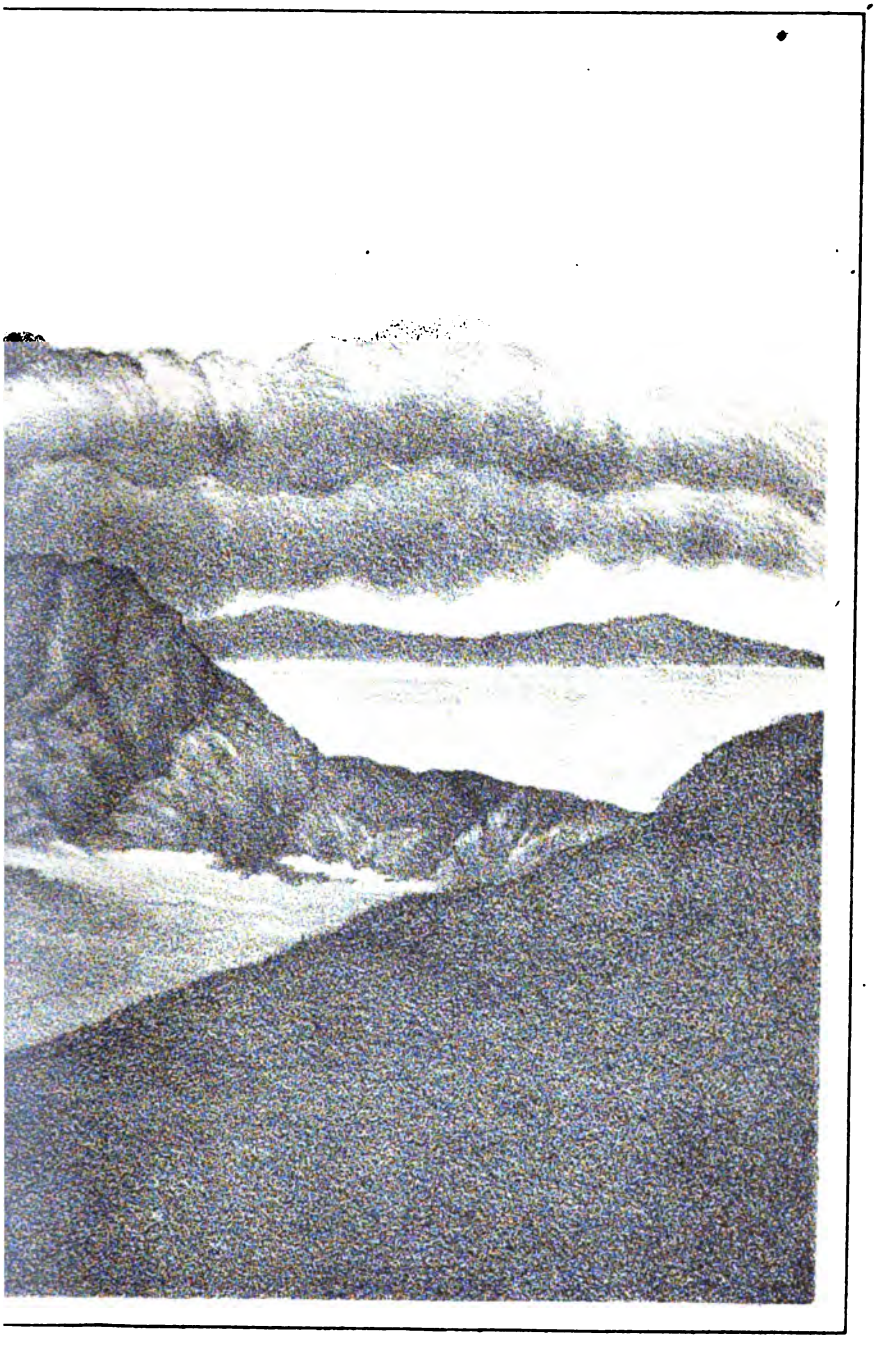
The greatest length of the island of the volcano is from North-east to South-west and is about five miles (Spanish), and the height of the edge of the crater is on the South-eastern side 190 metres, and on the Northern side 275 metres. The general form of the edge of the crater is approximately oval, (Fig. 3) with its major axis 2600 metres long. The interior surface is that of an inverted truncated cone, whose height is approximately that of the edge of the crater above the water of the lake, and whose smaller base is the bottom of the crater. There are several small cones on the floor of the crater of which only one is active, and this one throws out great quantities of vapor. There are also two boiling lakes, with metallic oxides and salts in solution, which color the smaller one a pure emerald

green, and the larger one a reddish yellow.

In the larger lake every few hours the center is blown up like an immense bubble, which rises one, two, or three metres above the surface and finally bursts, revealing a black orifice and making the boiling water appear all imaginable colors.

It is impossible for us to describe the beauties of the crater, whose bottom and interior walls, accessible at various points, present such varied structures and colors, from the black and compact basalts to the fragile, spongy, and almost transparent modern scoriae. The most finished description would not give even an approximate idea of that grand amphitheater, where every stone has its history, having been thrown thousands of times up to great heights, and having been dissolved and deposited until there are multitudes of transparent and colored crystals. In the sketch which has been given, the relative situation of the various parts of the crater may be seen.

The changes which this volcano has undergone and the disasters which it has caused since historical times are very remarkable. According to the chronicles of the time of the conquest, the crater was then on the South-western point of the island of Puló Volcan, having a cone which exists today and is called Binintian-Malaquit. A few years after the conquest that crater ceased acting, and another appeared on the Eastern side of the island, which in 1716 was submerged, leaving above the surface the two islands Bubuin and Nampayon. Then a new crater appeared on the Eastern side of Puló Volcan, which was gradually enlarged toward the West until the present crater was formed, which has not varied much since 1754. Among the various eruptions since the conquest, the most notable are that of 1749 where the village of Salá disappeared, and that of 1754, the greatest of all, when the villages of Taal, Lipa, and Tananang which were then on the shores of lake Bombong all disappeared. All the eruptions have consisted of showers of burning ashes and scoriae, between which showers great blocks of basalt were thrown out, covering the whole region to a depth varying from a few centimetres to two or three metres, and causing the different strata of volcanic material which can be se en throughout the province. We know of no observations



ORTE DEL MISMO

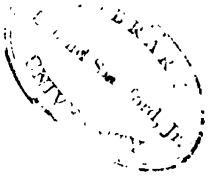
green, and the larger one a reddish yellow.

In the larger lake every few hours the center is blown up like an immense bubble, which rises one, two, or three metres above the surface and finally bursts, revealing a black orifice and making the boiling water appear all imaginable colors.

It is impossible for us to describe the beauties of the crater, whose bottom and interior walls, accessible at various points, present such varied structures and colors, from the black and compact basalts to the fragile, spongy, and almost transparent modern scoriae. The most finished description would not give even an approximate idea of that grand amphitheater, where every stone has its history, having been thrown thousands of times up to great heights, and having been dissolved and deposited until there are multitudes of transparent and colored crystals. In the sketch which has been given, the relative situation of the various parts of the crater may be seen.

The changes which this volcano has undergone and the disasters which it has caused since historical times are very remarkable. According to the chronicles of the time of the conquest, the crater was then on the South-western point of the island of Puló Volcan, having a cone which exists today and is called Binintian-Malaquit. A few years after the conquest that crater ceased acting, and another appeared on the Eastern side of the island, which in 1716 was submerged, leaving above the surface the two islands Bubuin and Nampayon. Then a new crater appeared on the Eastern side of Puló Volcan, which was gradually enlarged toward the West until the present crater was formed, which has not varied much since 1754. Among the various eruptions since the conquest, the most notable are that of 1749 where the village of Salá disappeared, and that of 1754, the greatest of all, when the villages of Taal, Lipa, and Tananang which were then on the shores of lake Bombong all disappeared. All the eruptions have consisted of showers of burning ashes and scoriae, between which showers great blocks of basalt were thrown out, covering the whole region to a depth varying from a few centimetres to two or three metres, and causing the different strata of volcanic material which can be se en throughout the province. We know of no observations

RTE DEL MISMO



which would show the relation of earthquakes to the eruptions up to 1874; but since that date we are able to give a few, which, as well as some of the facts already stated, we owe to the kindness of the curate of Talisay, Father Celestino Redondo.

On the 17th of May 1874 there was an eruption of black smoke and ashes unaccompanied by an earthquake.

On the 19th of July in the same year there was an eruption of gases, which were so sulphurous that the characteristic odor was perceptible as far as the town of Talisay. A great herd of cattle died on the island of Puló Volcan, on whose Western shore there was abundant vegetation which was mostly burned up. There was however no earthquake.

On the 24th of June 1877 from one until half past six in the morning, seven heavy earthquakes were felt, which were violent enough to cause cracks in the wall of a convent. These earthquakes were felt in Silan in the province of Cavite, but in many villages of Batangas they were not observed. They were not followed by any eruption.

From the last of October 1878 until the 12th of November, subterranean noises were heard frequently in the direction of the volcano. On the day mentioned an eruption began which lasted until the 15th and covered the whole island of Puló with a shallow layer of volcanic ash; there was however no earthquake.

Finally from the 8th of June 1880 the volcano was observed to be more active than usual, and some nights the crater was covered with a glare; and on the 17th, 18th, 19th, 20th, and 21st of July subterranean noises were heard and from time to time a small ball of fire (about half a metre in diameter) appeared above the crater; these balls burst at quite a height into small fragments a part of which fell back into the crater and the remainder upon the exterior slopes.

We might say much more of this volcano whose sphere of action in geological times must have been much greater than in historical times; perhaps then the lake of Bombong was the crater. But this would carry us too far from our present purpose, so we repress our desire until a more opportune occasion.

Province of Tayabas.

We travelled through this province setting out from Santo Tomas in Batangas and going in the direction of San Pablo; and we then passed through the villages Dolores, Tiaon, Sariaya, Candelaria, Tayabas, and Lueban all situated on the slopes of the two great volcanic promontories called Majaijai and Banajao.

From Lueban we passed over to the Pacific coast, which is a continuation toward the South-east of the coast of La Infanta, and inspected the towns of Mauban and Atimonan; crossing lastly the narrow isthmus which separates the Pacific Ocean from the sea of Mindoro, we arrived at Laguimanoc, whence we set out for Camarines.

During this journey we observed that the intensity of the July earthquakes decreased from the Pacific coast towards the West. In the towns named, with the exception of Mauban and Atimonan, we did not observe any important effects either in the buildings or ground, the only damages being slight cracks which did not render the buildings uninhabitable. In a single convent, that of Tiaon, which for some time past had not been occupied on account of its dilapidated condition, a part of the roof fell in; the church which was near the convent was also in a bad condition, but it resisted the action of the earthquake and continued to be used. Neither in Tayabas, nor in Lueban, nor in Sariaya where, besides the church and convent, there are many other masonry buildings with tile roofs, were left any marks of seismic action from the earthquakes of July, which were however felt in as great numbers as in Manila, although with much less intensity.

We will only give a few effects which were observed in Mauban and Atimonan on the Pacific coast, where the phenomenon assumed some importance.

Provinces of Camarines and Albay.

Although this description may appear long, we have thought it necessary to go into details, so that the reader could form his own opinions on the course of the phenomena, independently of our ideas. To bring the account to an end,

we will add a few words about the two provinces named above, in which there was a great diminution in intensity in proportion as the earthquakes had travelled toward the South-east; so that at the extremity of Luzon, near the straits of San Bernardino, there are places where the earthquakes of July passed unobserved.

In North and South Camarines the shocks had considerable intensity in all the villages in the North-eastern parts, but did not however injure any buildings or cause any marked disturbances of the ground. In Nueva Caceres, the capital of South Camarines, where there are many masonry buildings some of which are of great size, as the government house, the bishop's palace, churches with high towers, &c., we were shown as the greatest damage which was caused in that place a small crack in one of the walls of the government house. This crack was even smaller before the local earthquakes of the volcanic region of Mayon, which were felt here in last November, and which opened the crack somewhat. In the other places to the South-east of Nueva Caceres as far as Albay, the intensity was even less. The earthquakes seem to have been entirely extinguished in the line of volcanoes which begins with one called Ysaró and ends with Bulusan, and includes those called Yriga, Masaraga, Bulic and Mayon, the last of which has a height of 8000 ft., and has concentrated in itself all the volcanic activity of the whole region. All this locality is frequently disturbed by local earthquakes which do not generally pass out of South Camarines, and ordinarily are preceded by some eruption, or at least some notable variation in the activity of the volcano.

IV

General Deductions.

If, in some of the places examined in the different latitudes of Luzon, the earthquakes had been registered with accuracy, as they were in Manila, by seismometers, nothing would have been easier than to have traced on the maps the lines which mark the zones of relative intensity; but, lacking these observations, and obliged to estimate the direction and force of the motions by the effects which they produced in each locality,

we have great difficulty in presenting the deductions which indicate generally the character of the phenomena. We shall do it however because, besides fulfilling our obligations, our opinions will leave the reader completely free to form his own ideas; and from the minute and trustworthy observations which we have here recorded he can test or modify the deductions which we make.

We first call attention to this fact, that all the earthquakes from the 14th to the 25th of July can be divided into three classes corresponding respectively to the 14th, 18th and 20th days; and that each of these classes has its own special zone of maximum intensity. The first, which includes all the earthquakes which occurred between the 14th and the 18th, had its greatest intensity on that part of the Pacific coast which corresponds to the district of La Infanta and the province of Tayabas, and on that part of the shore of lake Bay between Santa Cruz and Morong. Leaving this region of maximum intensity, which we have marked on the map with a red line, the intensity became less and less until in Pangasinan in the North, and Camarines in the South, the earthquakes in many towns were not noticed.

The second class, which on account of its great intensity and extentis the most important of all, had its maximum intensity in the territory included between the Western coast of Tayabas and La Infanta and the most Western spurs of the mountain-chain which beginning at Baler runs towards the South and ends in the volcanic mountains of Tayabas near the narrow isthmus of Atimonan. The seismic waves in this great shock had much greater extent and intensity toward the North-west than toward the South-east; in the first direction including all the island of Luzon and probably part of the China Sea between Luzon and Formosa, while in a South-easterly direction the seismic action was entirely extinguished before reaching the Straits of San Bernardino, so that the loss of intensity must have been much more rapid. It can be calculated that the surface more or less violently disturbed by the earthquake of July 18th, deducting the part on the ocean as we have no exact observations as to its boundaries, was

about 357 square leagues.* On the map we have drawn black lines to show the different places at which the intensity was the same. According to observations made in our journey the region of maximum intensity was in Nueva Ecija, the mountains of Bulacan and Morong, the district of La Infanta and a part of the province of La Laguna, all of which territory is included in the inside curve.

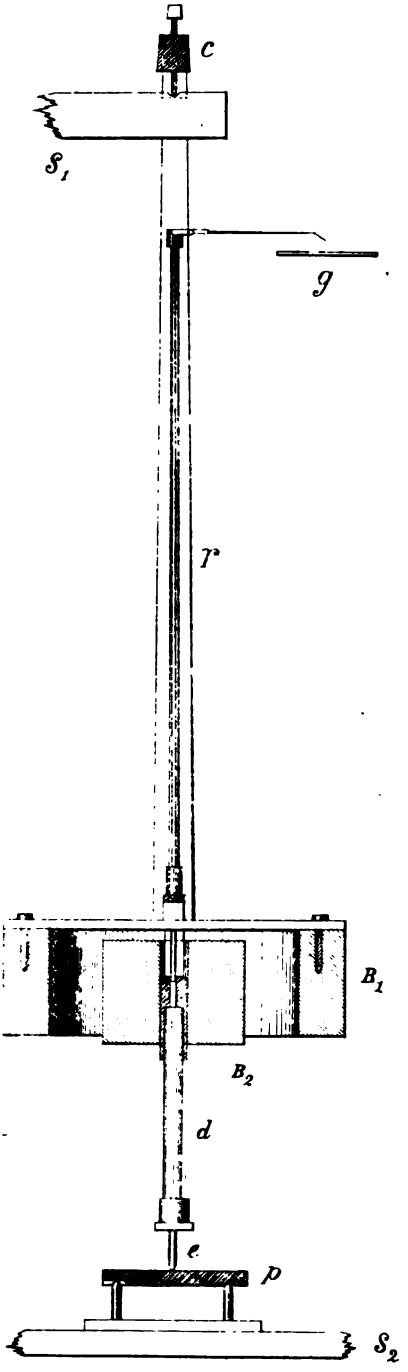
In the determination of the curves which limit the successive zones, we have endeavored to draw them so that they include all the points at which the effects observed, by careful estimate, were about the same, rather than to make them represent the course of the seismic waves; it would have been impossible for us to do the latter, as we had no more exact observations than could be obtained from ruined buildings and disturbances of the ground.

Finally the third group, which includes all the earthquakes which happened on and after the 20th, presents a very small zone of maximum intensity, in spreading from which the motion decreased so rapidly that while the greatest action was on the Western shore of Lake Bay, or perhaps in Manila, in the adjoining provinces toward the North and the South, that is in Pampanga, Nueva Ecija, Batangas and Tayabas, that shock was hardly distinguished from the other slight shocks which were felt from the 18th to the 25th of July. On the map we have drawn a yellow line including a small part of Lake Bay and a short stretch of its Western coast, the peninsula of Jalajala and the island of Talim; and this line incloses the region of maximum intensity, where the action of these earthquakes was much greater than in the other parts of the province of Manila, and where they were especially violent at points South of the Pasig river. In speaking in detail of this province we have called attention to the singular fact that this Pasig river seems to be a dividing line between two districts in which the intensity of the earthquake of the 20th was very different; this fact is our reason for drawing one of the curves to coincide with this river.

April 1881. JOSÉ CENTENO.

* 56000 square miles. [*See note on next page.*]

NOTE. The figures referred to in the first section of chapter 1, are already known to the Seismological Society of Japan, and for that reason have not been given.


C
S_1
g
r
B_1
B_2
d
e
p
S_2

SEISMOLOGICAL NOTES.

BY

PROF. J. A. EWING.

[READ NOVEMBER 21ST, 1882.]

I. *A Duplex Pendulum Seismometer.*

The fault of the common pendulum when used as a seismometer is its too great stability. This may be reduced enough to fit the instrument for seismometric work by making the length of the pendulum inordinately great, as was in fact done in the pendulum seismometer which I had the honour to describe to the Society in 1880*. But a very long pendulum presents, in its construction and use, so many difficulties as to be almost impracticable, and methods have been suggested by Mr. Gray † and also by myself ‡ whereby a short pendulum may be brought to a state of neutral or nearly neutral equilibrium. The "Duplex Pendulum" which is now exhibited to the society achieves this result in an entirely new way.

Briefly the idea of the new instrument is this. The common pendulum is stable: an inverted pendulum with pivotted supporting rod is unstable: by placing an inverted pendulum below a common one and connecting the bobs so that any horizontal displacement must be common to both we may make the equilibrium of the jointed system neutral or as feebly stable as may be desired.

The figure shows a vertical section through the instrument. B_1 is the bob of the upper or common pendulum consisting of a hollow cylinder of lead, which is hung by two light wooden rods from a cross piece c in which a steel pin is

* *Trans. Seis. Soc. Jap. Vol. I. p.* 38.

† *Trans. Seis. Soc. Jap. Vol. III. p.* 146.

‡ *Ibid. p.* 147.

fixed which stands in a conical cup of agate in the fixed support S_1. This gives the pendulum freedom to oscillate in any azimuth. B_2 is the bob of the lower or inverted pendulum. It is fixed to a stout circular rod d which is pivotted to a second fixed support or base S_2 by a somewhat peculiar joint. Two feet e fixed to the rod of the inverted pendulum stand respectively in a conical hole and V slot on the upper surface of a steel plate p, on the lower surface of which there are another conical hole and V slot in a line at right angles to the line of those on the upper surface. Into the lower hole and V a pair of inverted feet fixed to S_2 press up. The upper and lower slots and Vs are arranged so that their vertices are all in the same horizontal plane. This mode of support also gives freedom to oscillate in any azimuth, and it is employed instead of the more simple method of pivotting a single foot in a single conical hole in order that there may be no freedom on the part of the lower pendulum to rotate about a vertical axis. There is therefore no objection to using a prolongation of the lower pendulum as the indicating pointer. The bods B_1 and B_2 are connected thus: from a rigid brass bar extending across the top of B_1 there depends a rigid vertical projecting piece ending with a spherical ball which just fits in a cylindrical hole in a tube fixed to B_2. The pendulums therefore move freely together, this joint giving them the necessary power of vertical sliding relatively to each other through a small distance.

The spherical ball on B_1 and the tube on B_2 are placed so that their point of contact is at the centre of percussion of both pendulums. This is the *kinetic* condition which must be fulfilled in order that this point should be the "steady point" when a displacement of the earth occurs. The point of contact is of course a short distance below the centre of gravity of B_1 and above that of B_2.

If for brevity we call W_1 and W_2 the weights of the pendulums referred to this point (that is, the actual weignt of each multiplied by the distance of its centre of support from its centre of gravity and divided by the distance of its centre of support from the point of contact between the ball and

tube, then the *static* condition which will give neutral equilibrium in very small displacements is that

$$W_1 l_2 = W_1 l_2$$

where l_1 and l_2 are the lengths of the pendulums measured from their point of contact to their respective points of support. In practice a small margin of stability must be given by making $W_1 l_2$ somewhat greater than $W_1 l_2$.

The indicating pointer consists of a light wooden rod r forming a prolongation of d. At the top of this a light projecting arm is hinged and stands out horizontally with its end (steel-tipped) touching a smoked glass plate g. The ratio of multiplication of the record is the distance from the hinge to the lower pivot divided by l_2.

When its equilibrium is nearly neutral the duplex pendulum forms an exceedingly sensitive level. If the line joining the upper with the lower point of support is not perfectly vertical a very large deflection of the pointer results. It is easy to show mathematically that if the equilibrium were exactly neutral when the line joining the supports is vertical the apparatus would be unstable should any deflection of this line from the vertical take place, and that when there is some small stability the effect of such a deflection is to cause a large displacement of the bobs. The same characteristic is however shared by other neutral or nearly neutral equilibrium seismometers, such as the rolling sphere or the horizontal pendulum.

The instrument now shown to the society has been too recently constructed to allow me to give any account of its performance in an actual earthquake, but when tested by means of a shaky table it appears to work very well.

II. *The Suspension of a Horizontal Pendulum.*

The method of support hitherto adopted in my horizontal lever seismometers has been to use a rigid frame pivotted by joints at two points nearly in the same vertical line. In place of joints we may use flexible connections, since the actual angular displacement is never large, just as in clock pendulums a spring suspension is commonly used in place of a hinged

joint. Mr. Gray has described a modification of the horizontal lever called by him a conical pendulum seismometer, in which the frame of the level is reduced to a single strut and tie, the strut being set horizontally with its end jointed to a fixed support and the tie consisting of a wire fixed at its upper end, so that its flexibility and torsional elasticity make it serve as a substitute for a second joint. Recently I have gone a step further, and have introduced a flexible spring or wire in place of the other joint also. To do this it is only necessary to fork the strut and carry it out beyond the vertical axis of support and then tie it back to the axis by a flexible spring, preferably a steel band with its flat side vertical. The wire tie intersects the vertical line through the centre of gravity of the mass at a point horizontally in front of the lower point of support to which a prolongation of the strut at the back is tied by a flat steel band. A fixed pin sliding freely in a slot on the strut is added to prevent any bodily translation of the strut to one side or other during an earthquake, and hence the hanging mass has no other freedom than that of rotation about the nearly vertical line joining the upper and lower points of attachment. So far as can be judged by recent experiments this arrangement offers less frictional resistance than the method of support by pivots, and any change which gives a diminution of friction is an improvement in a seismometer.

III. *A Speed Governor for Seismograph Clocks.*

The fluid friction governor shown to the society on a former occasion possessed the defect that the balls (whose centrifugal displacement caused fans to be immersed more or less deeply in a trough of oil) were liable to be disturbed by an earthquake, so that the action of the governor became to some extent irregular at the very time when uniformity of speed was most necessary. A modified form which has been recently applied to the clock of the seismograph in Tokio University overcomes this difficulty successfully. Instead of two balls two pairs of balls are used, fixed at the ends of links which cross the spindle X-wise. The upper ends of the links

also carry the fans whose immersion in oil checks the speed. A pair of springs resists the centrifugal tendency of the balls. The centre of gravity of each link with its attached balls coincides with the joint between it and the spindle, and consequently the shaking of the clock during an earthquake produces no change in the configuration of the governor. The effect of an earthquake on the oil in the trough is immaterial, both in this and in the older form.

NOTES ON THE EARTHQUAKE AT ATAMI, IN THE PROVINCE OF IDZU, ON SEPTEMBER 29, 1882.

BY

T. DAN, S.B.

[READ Nov. 21ST 1882.]

On the morning of Sept. 29, a severe and sudden shock of earthquake was felt at Atami, causing much alarm to the people and leaving after it, as the effect of its violence, considerable amount of damage in the town and its neighborhood.

Nobody seems to have felt any feebler shocks precede the heavy one, which startled us from our sleep about 5 o'clock or a little before. An intelligent fisherman told me, however, that when he was returning in a boat, in company with another, about the same time from the fishing port of Aziro, about 5 miles south of Atami, he distinctly heard a roaring sound in the mountains and immediately after, felt his boat shaken violently. As the time was early and almost every one was yet asleep, I found no one else to confirm his statement. I am sorry that I could not record a more definite time of the shock, on account of confusion caused by its severity and suddenness. The duration of the shock seemed very short, probably lasting only a few seconds. I felt as if the shock consisted of a series of rapid vertical thrusts. Servants in the house who were up at the time said that they all held on to something for fear of falling over. I may add here that bottles containing medicine fell off the shelf at the house of a town physician, causing so much damage that his patients were deprived of their medicines for two days till he obtained an extra supply from Odawara. On examining my *ando*, a Japanese lamp, the description of which would be familiar to every foreigner who

has been in Japan,* I found the paper which cover
side facing the sea or E. S. E. was saturated with oil sh
that the oil was thrown out on the side toward the sea.

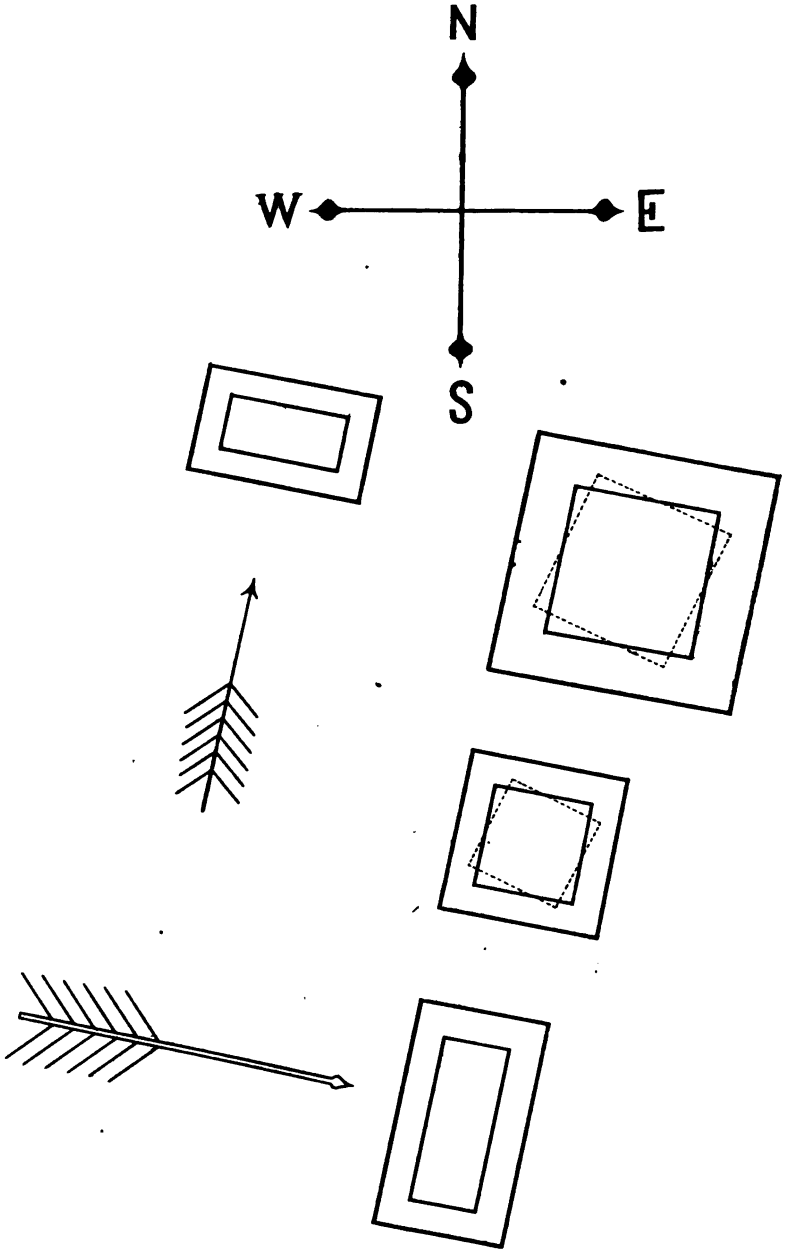
In order to show the effects which the earthquake
duced, a brief description of the physical structure of A
and neighboring coast is necessary.

Atami is built on the slope rising with quite a
inclination from the sea in a valley formed by the spu
Hakone ranges, which project out into the sea like a
enclosing the town of Atami between them. On the s
side particularly, the mountain terminates in cliffs of g
height and abruptness. The houses are mostly on terra
built successively from the sea. In fact, the coast of
rises out of the water perpendicularly, thus making the ro
way along the coast extremely difficult. The road fr
Odawara to Atami, a distance of about 16 miles is cut throu
mostly along the sides of cliffs, in many places several hundr
feet above the sea.

On going out to look for any damage that might hav
been done, I found that in numerous places, stones were throw
entirely down from their positions in the nearly vertical retai
ing walls of the terraces. In a similar manner, a soli
retaining wall about 5 feet high above which one of the pri
cipal hotels, called Suzukiya, is built, was nearly destroyed o
the side facing the sea. A little house in front of our hot
was twisted out of shape by the stones giving way beneath.
must not omit to say, however, that the stones are mostl
rudely cut and loosely laid in the walls, without mortar, bu
those forming the walls at the hotel were well shaped an
closely fitted, though not cemented.

I noticed that the greatest damage to the terraces, was i
the sides facing the sea or E.S.E.; a few cases in those facin

* *The lamp I had essentially consisted of a shallow box about one fo
square with four small posts about three feet high, erected in its corne
and braced together at the top by pieces of wood; above the middle, th
framework was papered over, having in the inside a narrow piece of boar
fixed across to hold a copper saucer containing oil with a little wick hangin
over the edge.*


N
W
E
S

N.E. & S.E. but scarcely any in those facing S. or S.W. As the land rises towards the W. and N., I found scarcely any walls facing in those directions and no cases of damage in them.

Although most of the walls face E.S.E. and therefore we can hardly tell by the amount of damage, the side which suffered the most, yet it appears most probable that the side facing E. S. E. had to bear the greatest shock.

I have come to the same conclusion as to the direction of the shock by the consideration of the fall and rotation of tombstones in the graveyard of Onsenzi, which I was fortunate enough to observe in their displaced positions, as the workmen were already employed in replacing them properly.

The temple of Onsenzi is located quite a distance up from the sea in an elevated situation with terrace walls on N.N.E. and E.S.E. sides. Just in front of the temple a monument erected in memory of a historical personage Fujiwara Fujifusa, facing N.N.E., fell forwards and was broken. It was a broad irregular flat slab about 6 inches thick, measuring about 5 feet high and 3 feet wide, set into a hole made in the stone base.

Some of the smaller tombstones, which simply rested on flat bases and through bad cutting or disintegration were unstable fell from their pedestals, all toward E.S.E., with the exception of two flat ones facing N.N.E. which fell forwards in the same direction as the monument.

I observed also the interesting case of tombstones rotating on their bases, all in the same direction as that of the hands of a watch. The tombstones all stood in rows parallel to each other and the approximate displacement and the directions of the fall can be seen in the accompanying diagram, the dotted lines indicating the rotated positions; the large arrow shows the direction of the fall of the tombstones and the small arrow that of the monument and the two tombstones mentioned above.

The maximum amount of rotation observed was about 20°, the amount apparently decreasing as the weight of the stones increased.

The simple explanation of rotation of columns given by Prof. Milne in Vol. I of the transactions of this society can be

applied to this case, regarding the movement as caused by a direct shock, or we can imagine this singular movement as due to the rotary motion of the ground, probably caused by the interference of transverse waves. If we consider the shock as coming from the direction of the sea, the production of the reflected waves could reasonably be accounted for, by the sudden reflection against the dense rocks of which the mountains are composed. The comparative violence of the shock felt here may also be due to the same cause, or to the fact that the origin of the shock was comparatively near.

From what has been recorded we have evidences to infer that the general direction of the shock was either W.N.W. and E.S.E. or W.S.W. and E.N.E. or nearly E. and W. which agrees with the direction indicated by Prof. EWING's astatic lever seismograph in the engineering laboratory of the *Daigaku* on the morning of that day. The seismographic record shows that there was hardly any motion of the lever which traces the N. and S. component, whereas the one indicating the E. and W. component undulated considerably through the comparatively long interval of 69 seconds. On making inquiries about the earthquake at every place where I stopped, I found that the intensity was less and the duration longer than was felt at Atami; at Kanagawa, a man particularly remarked about it, as an unusually long shock. Whether the earthquake recorded in Tokio is the same as that felt at Atami is doubtful, yet it is reasonable to believe that they were the same or at least had originated from the same source as a shock was felt everywhere about the same time, on this side of the Hakone as far as I could ascertain.

We had several smaller shocks after the heavy one I have described; I have recorded one at about 9 and another a little before 12 in the morning of the same day. We were alarmed again about 2 A.M. of Oct 1 by a shock. In the mean time I am certain of feeling slighter ones, whose times of occurrence I have not recorded. About 10 A.M. of Oct 5th I felt a distinct shock.

The frequency of the shocks felt, the comparative violence of the first one with the short duration of apparently rapid

vibrations, all favor the supposition that the origin of the shocks was near; the waves may have been propagated from a source somewhere in vicinity of Atami, decreasing in amplitude and energy in proportion to the distance traversed, Friends of mine who were in Kiga on the Hakone mountains tell me that they do not remember feeling any shock that morning, which shows at least that the origin was not in that part of the range.

Being interested in the nature of the mineral springs, I made immediate inquiries as to the action of the big spring or *Oyu*, after the shock. I found that there was no change in the usual periodicity and amount of discharge until two days after, when, on Oct. 1 the discharge continued unceasing for the whole day, which I was informed happens very rarely. This fact may be explained by supposing that the large amount of infiltrated water, derived in great part from the extraordinary heavy rain of Sept. 30th and Oct. 1st, produced an unusual amount of steam and boiling water sufficient to cause this continuous discharge under the influence of unusually great subterranean heat, which might likely prevail at the time of earthquakes, as is evidenced by the sudden increase of temperature in the certain thermal springs; as for instance, at the time of the earthquake of the island of Ischia in the bay of Naples in 1828 the hot springs of Rita which was near the centre of the movement, were ascertained by M. Covelli, to have increased in temperature.(1) After the great New Zealand earthquake in 1855, the natives alleged that the temperature of Taupo hot springs was sensibly raised just before the catastrophe.(2) Concerning the elevation of subterranean temperature, Lyell says "Thermal and mineral springs are abundant in countries of earthquakes and active volcanos. Lastly, springs situated in districts considerably distant from volcanic vents have been observed to have their temperature suddenly raised or lowered, and the volume of their water increased or lessened by subterranean movements. etc. etc."

(1) *Lyell's Principles of Geology vol. II p.* 94.

(2) " " " " " " *p.* 87.

On the 3d, however, the spring had resumed its normal condition. Some say that the rainfalls generally increase the amount of discharge, which if true goes to show that the spring is not entirely of marine origin.

It seems qnite reasonable to infer that the spring water owes its origin partly to the sea water and partly to the fresh water infiltrations.

Although a digression, let us compare by the use of the following table, the composition of the spring water as analysed by Dr. MARTIN at Shiyakujo and those of the varieties of sea water collected at different localities, to show the analogy existing between them without discussing them in detail.

(Contained in 1 litre)

Localities	Na	Cl	Mg	Ca	K	So_4	Br	Co_3	Fe	Mn	Sio_2	org. mat.	Residue	Authors
Atlantic Ocean 41° 18′ N—36° 28′ W	gr. 11.719	gr. 20.840	gr. 1.1981	gr. 0.5568	gr. 0.6682	gr. 3.029	gr. 0.3878	gr. „	gr. „	gr. „	gr. „	gr. „	gr. 38.400	BIBRA, *Ann der Chem. u. Pharm.* t. LXXVII
Pacific Ocean 3m, 50 from the surface	10.262	18.950	1.3151	0.4719	0.6038	2 786	0.3102	„	„	„	„	„	34.700	BIBRA, *loc. cit.*
Black Sea South side of Crimea	5.512	9.574	0.6622	0.1305	0.0975	1.2505	0.005	0.2475	0.1271	„	„	„	17.605	GÖBEL, *Poggendorff's Ann., suppl.* t. I, P. 187
Sea of Azof between Kertch and Mariopol.	3.997	6.585	0.4010	0.0908	0.0670	0.8045	0.004	0.0695	0.0358	„	„	„	11.900	*Ibid.*
Atami Big Spring (Ōyu)	1.491	6.034	0.5894	0.6945	0.9493	0.1362	trace	0.0053	0.0009	trace	0.1100	trace	10.010	MARTIN, *Mittheilungen der Ostasiat. Gesellschaft* July 1876
Caspian Sea South West of Pischnoi	1.144	2.737	0.4098	0.1916	0.1397	1.337	?	0.0773	0.0401	„	„	„	6.296	GÖBEL, *Poggendf. Ann., suppl.* t. I

We find that the total residue of the spring is much less than those of the different samples of the ocean waters generally. Now, we ought rather to expect it more on account of concentration by evaporation etc, but the fact that it is less seems to indicate that the sea water is considerably diluted before being discharged.

The comparatively large amount of silica, SiO_2, in the spring is due, no doubt, to the decomposing action of the hot water upon the trachytic rocks underlying Atami through which it has percolated, as is the case in the majority of thermal springs passing through silicious formations.

It seems to be of great value for the proper discussion of the subject to have the analyses of the spring water and those of the sea water near the coast, made from time to time through the varying seasons of the year.

After the shock, however, the little spring called *Kobayashi no yu* which fed the bath of our hotel, was nearly stopped up, discharging but a small amount of muddy water to the general dissatisfaction of the guests and the alarm of the host. On examining the spring, I found that the water did not rise high enough in the basin to be conveyed by the aqueduct. They lowered the aqueduct, which involved considerable trouble, but by doing so the usual supply was obtained. On examining the action of the spring, which is generally intermittent with an interval of 2 minutes or so, I found that it had accelerated its eruptions becoming almost constant but apparently decreased in force.

This fact might be explained by supposing that the tube which conveys the water was distorted and contracted by the recent earthquakes thus hastening the interval of eruptions, just as BUNSEN explained the action of geysers, the truth of which was afterwards experimentally confirmed by Dr. TYNDALL; that is, the tube itself being sufficiently accountable for the production of periodic eruptions, any obstruction of the tube would, by causing the heat to accumulate, tend to hasten the eruptions.

The large amount of boiling water discharged periodically from the *Ōyu* accompanied with clouds of steam and growl-

ing subterranean noise is the object of much wonder and speculation to all who see it during its action. The eruptions take place quite regularly about 5 times in a day lasting for half an hour or more. A few hours before the final eruption clouds of steam begin to issue from the mouth of the tube and the water rises to the rim of the basin, and for a considerable length of time the level of the water in the basin oscillates up and down. The oscillations increase in frequency and force till followed by a number of minor eruptions of shorter duration, the water receding into the tube after each outburst, and commencing again the similar actions with added force and increase in the volume of the discharged water, and so repeating itself again and again till it ends in the final eruption.

This peculiar oscillating action of the spring does not essentially contradict, even if it does not favor, the theory that the intermittency is due to the formation of steam in the lower part of the tube, as proposed by BUNSEN and others to account for the action of the geysers.

The percolated water coming in contact with heated rocks or superheated steam, would be partly converted into vapour, which in turn will heat up an additional amount of water till the tube full of water will be raised to a high temperature. As the water in the lower part of the tube receives more heat, a sudden rise of temperature, however slight, may cause the water to overcome the pressure and flash into steam which would tend to rush up the tube, carrying the column of water with it; but the enormous pressure of the column would condense part of the steam, which will cause the column to sink down again into the tube. This conflict, so to speak, of steam and the pressure of the water would last for some time and may give rise to the oscillatory movement above described.

At length, however, the tension of the steam becomes so great that the column of water is no longer able to resist it, and it will be pushed out, at first, spasmodically; but as the lower portion becomes relieved of part of its weight and is rapidly converted into vapor, the action will become more violent, till the whole of the column is expelled.

When the expansive power of steam is thus exhausted,

the sea water may rush into the tube through the underground fissures and may partly fill up the tube; at the same time the rain water may be infiltrating into it. The existence of underground fissures from the bottom of the sea near the coast, is evidenced by the fact that the sailors and fishermen often feel the hot water bubbling up from the bottom.

On my way back, I found that the road between Atami and Odawara had suffered some damage, landslips obstructing the passage in many places, which were no doubt caused by the recent rain aided by the previous earthquake, as in Atami where we found that the rain greatly extended the damage begun by the earthquake.

I must say that as the construction of the houses, terrace walls, &c, is rough and primitive with few exceptions, the amount of damage done here would be far greater than the same intensity would have produced on level ground or in more solid structures or in places where stone constructions are few.

Having no intention of writing this brief note at the time, I must apologize for the inaccuracies both as to time and measurements.

SEISMOLOGICAL SOCIETY OF JAPAN.

CONSTITUTION.

[CORRECTED TO 1883 JAN. 1.]

1.—This Society shall be called the *Seismological Society of Japan.*

2.—The objects of this Society shall be the furtherance of the study of, and the collection of facts relating to all the phenomena connected with *earthquakes* and *volcanoes.*

3.—At the meetings of the Society papers on general science may be read, subject to the approval of the Society.

4.—This Society shall consist of *Corporation*, *Honorary* and *Ordinary* members.

5.—*Honorary Members*, who must be non-residents in Japan, shall be admitted on grounds to be determined by the Committee.

6.—
7.— } Cancelled.

8.—The annual subscription shall be due on January 1st, and shall be, for members who receive the English *Transactions*, 8 *yen*, or £ 1., or $ 5. Japanese members who live in the interior may receive only the Japanese *Transactions*, and in that case the annual subscription shall be 4 *yen*.

9.—The Officers of the Society shall be a *President*, a *Vice-President*, a *Foreign Secretary*, a *Japanese Secretary*, a *Foreign Treasurer*, a *Japanese Treasurer* and five *Ordinary Members*, two of whom shall be residents of Yokohama. These eleven shall form the Committee, of whom four shall form a quorum. The Chairman of the Committee shall have a deciding vote.

10.—The affairs of this Society shall be managed by the Committee, who shall also decide on the papers to be published in the *Transactions* of the Society.

11.—General Meetings, due notice of which shall be given to the Members by the Secretary, shall be held at convenient dates in Tokio or Yokohama.

12.—The Officers of the Society shall be elected each year by ballot at an Annual Meeting.

13.—The Committee shall hold a Meeting one week before each General Meeting.

14.—At the Annual Meeting the Secretary and the Treasurer shall present their Reports.

15.—Any amendments to this constitution may be proposed at any General Meeting, and shall be considered at the next, when, if two-thirds of the Members are present, it may be passed by a majority vote; if however two-thirds of the Members are *not* present, and the majority of those present are in favor of the amendment, it shall be considered at the succeeding Meeting, when, if a majority of those present are in favor of the amendment, it shall be adopted.

16.—The Secretary shall notify Members of proposed amendments to the constitution.

RULES ADOPTED BY THE COMMITTEE.

[CORRECTED TO 1883 JAN. 1.]

1.—Every paper shall be submitted to the Committee, either in full or abstract, before it is put on the list of the Society for public reading.

2.—Any person presenting a paper to the Society shall be required to state whether he intends to publish it elsewhere.

3.—Each paper shall be submitted to a sub-committee who shall have power to recommend whether it shall be printed in the *Transactions* of the Society *by title, in abstract,* or *in full.*

4.—The printing, in the Society's *Transactions*, of remarks or criticisms upon papers read at any meeting, shall be limited substantially to what was uttered in public at such meeting; or if any new matter, in the way of further remark or criticism, is offered later, it must first be submitted to the Committee for their decision.

5.—To any new Member of the Society will be given one copy of all the volumes of the *Transactions* published after such Member joins the Society, and to any retiring Member the volumes including the papers read up to the time of such Member's resignation, if all his dues are then paid,

6.—To Members of the Society extra copies of the *Transactions* will be sold at the cost price of publication, which may be learned by application to the Secretary.

OFFICERS OF THE SOCIETY.

FOR THE YEAR ENDING

MARCH, 1883.

President—GENERAL G. YAMADA, MINISTER OF THE INTERIOR.
Vice-President—PROF. J. A. EWING.
Foreign Secretary—PROF. JOHN MILNE.
*Acting Foreign Secretary**—PROF. H. M. PAUL.
Japanese Secretary—PROF. D. KIKUCHI.
Foreign Treasurer—P. MAYET, ESQ.
Japanese Treasurer—N. KANDA, ESQ.

Members of Committee,
- *Tokio*: I. HATTORI, ESQ.; DR G. WAGENER.
- *Yokohama*: CAPT. F. BRINKLEY, R.A.; W. H. TALBOT, ESQ.

---

* During the temporary absence of the *Foreign Secretary* in Europe.

MEMBERS OF THE SOCIETY.

[CORRECTED TO 1883 FEB. 1]

Honorary Member.

HIS MAJESTY KING KALAKUA of the *Hawaiian Islands.*

Corporation Member.

The *Kayo Gakko*.....*Gifu Ken.*

Ordinary Members.

ABELLA Y CASARIEGO, DON ENRIQUE.....*Manila.*
ALEXANDER, PROF. T, C. E.. ....*Tokio.*
ARAI, I..... ,,
BAELZ, PROF. E., M. D. ..... ,,
BASSNET, THOMAS.....*Jacksonville, Fla., U. S. A.*
BASSNET, MRS. T. ..... ,, ,, ,,
BEADON, R. J.....*Tokio.*
BEUKEMA, T. W., M. D.. .....*Yokohama.*
BIAGIONI, F. ..... ,,
BLACKISTON, CAPT. T. W., R.A.. ..... ,,
BOLTON, PROF. H. C.....*Hartford, Conn., U. S. A.*
BRINKLEY, CAPT. F., R. A., EDITOR OF THE "JAPAN MAIL" .....*Tokio.*
BROWN, A. R.....*London.*
BROWN, COLVILLE..... ,,
BROWNE, H. St. JOHN. .....*Kobe.*
BRUSH, PROF. G. J.....*New Haven, Conn., U. S. A.*
CARCANO, COUNT SILVIO, H. ITALIAN M CONSUL.....*Yokohama.*
CASATI, LUIGI.....*Tokio.*
CHAMBERLAIN, B. H..... ,,
CHAMBERS, JOHN, C. E. ..... ,,
CHIOSSONE, E..... ,,
CONDER, JOSIAH..... ..... ,,
COX, W. D..... ,,
COX, PROF. E. T.....*San Francisco, Cal., U. S. A.*

DAN, T. ..... *Tokio.*
DIVERS, PROF. E., M. D. ..... „
EYKMANN, DR. J. F. ..... *Tokio.*
ELDRIDGE, STUART, M. D. ..... *Yokohama.*
ELGAR, F. ..... *London.*
EWING, PROF. J. A. ..... *Tokio.*
FENOLLOSA, PROF. E. F. ..... „
FUJIOKA, PROF. J. ..... „
FUJITANI, T. ..... „
FUKUOKA, H. E. T., MINISTER OF EDUCATION ..... „
FURUICHI, K. ..... „
FUTAMI, K. ..... „
GORDON, T. W., M. D. ..... *Georgetown, Ohio, U. S. A.*
GOTO, M. ..... *Tokio.*
GOTTSCHE, PROF. C. ..... „
GOWLAND, W. ..... *Osaka.*
GRAY, PROF. THOMAS. ..... *Glasgow.*
HAMAO, A. ..... *Tokio.*
HARKNESS, PROF. WM., U. S. N. ..... *Washington U. S. A.*
HATTORI, I. ..... *Tokio.*
HAWES, LIEUT. A. G. S., R. M. ..... „
HEGT, M. J. B. N. ..... *Yokohama.*
HOLTHAM, E. G., C. E. ..... *London.*
IRWIN, R. W. ..... *Tokio.*
ISAWA, S. ..... „
IWASA, PROF. I. ..... „
JAMES, LIEUT. J. M. ..... *Shinagawa.*
JUDD, PROF. J. W., F. R. S. ..... *School of Mines, London.*
KANDA, N. ..... *Tokio.*
KATAYAMA, T. ..... „
KATO, H., PRESIDENT OF TOKIO UNIVERSITY ..... „
KIKUCHI, PROF. D. ..... „
KNIPPING, E. ..... „
KOCHIBE, T. ..... „
KORSCHELT, O. ..... „

KOZIMA, PROF. N. ..... „
KUDO, S. ..... *Sapporo.*
KUKI, R., VICE-MINISTER OF EDUCATION ..... *Tokio.*
KUWABARA, M. ..... „
LYMAN, B. S. ..... *Northampton, Mass., U. S. A.*
MCCARTHY, J. W. ..... *London.*
MARTIN, G., M. D. ..... *Tokio.*
MARTIN-LANCIAREZ, E., H. ITALIAN M. CHARGÉ D'AFFAIRES .... „
MAYET, P. ..... „
MENDENHALL, PROF. T. C. ..... *Columbus, Ohio, U. S. A.*
MILNE, PROF. JOHN ..... *Tokio.*
MIYAKE, PROF. H. ..... „
MORI, J. ..... „
NAKAMURA, K. ..... „
NAKASHIMA, N. ..... „
NAMURA, T. ..... *Chiugakko Miyagi Ken.*
NAUMANN, DR. E. ..... *Tokio.*
NETTO, PROF. C. ..... „
NISHI, M. ..... „
OMORI, S. ..... „
OSBORNE, A. O. ..... *Waterville, N. Y., U. S. A.*
PALMER, LT.-COL. H. S., R.E., ... *London.*
PARKES, H. E. SIR HARRY S, K. C. B., K. C. M. G., H. B. M. MINISTER, *Tokio.*
PATON, GEORGE ..... „
PAUL, PROF. H. M ..... „
PRYER, H. ..... *Yokohama.*
RENNIE, SIR R. T, CHIEF JUSTICE OF H. B. M. SUPREME COURT FOR CHINA AND JAPAN .....
RINGER, F. ..... *Nagasaki.*
RODWELL, PROF. G. F. ..... *Wiltshire, England.*
RORETZ, A. VON, M.D. ..... *Yamagata.*
RUDLER, W. F. ..... *School of Mines, London.*
SATOW, E. M., 2ND SEC. AND JAPANESE SEC. OF H. B. M. LEGATION .... *Tokio.*
SEKIYA, S. ..... „
SHINAGAWA, Y., VICE-MINISTER OF AGRICULTURE AND COMMERCE. .... „

SNOW, H. J. ..... *Yokohama.*
SUGI, K. ..... *Tokio.*
TALBOT, W. H., EDITOR OF THE "JAPAN GAZETTE" ..... *Yokohama.*
TAPPAN, PROF. E. T. ..... *Gambier, Ohio, U, S. A.*
TODA, W. ..... *Tokio.*
TOMITA, T. ..... „
TUTTLE, PROF. A. H. ..... *Columbus, Ohio, U. S. A.*
URIU, T. ..... *Handa Silver Mines, Fukushima Ken.*
VAN BUREU, GEN. T. B, U. S. CONSUL GENERAL ..... *Yokohama.*
VAN DER POT, H.E. J. J., H. NETHERLANDS M. MINISTER PRESIDENT „
WADA, T. ..... *Tokio.*
WADA, Y. ..... „
WAGKNER, DR. G. ..... „
WOLFF, A., SWISS CONSUL-GENERAL ..... *Yokohama.*
YAMAGAWA, PROF. K. ..... *Tokio.*
YAMASHITA, D. ..... „
YATABE, M. ..... „
ZEDTWITZ, BARON F. VON, H. G. M. CHARGÉ D'AFFAIRES ..... „

Total, { Honorary Member, 1.
Corporation „ , 1.
Ordinary Members, 111.

ABSTRACT OF CONTENTS

OF THE

TRANSACTIONS of the Seismological Society of Japan.

Vol. I.

J. Milne,—*Seismic Science in Japan.* 35 pages.
J. A. Ewing,—*New form of Pendulum Seismograph.* 6 p., 3 plates.
T. Gray,—*Seismometer and Torsion Pendulum Seismograph* 8 p., 2 plates.
T. C. Mendenhall,—*Acceleration of Gravity at Tokio (abstract).* 2 p.
G. Wagener and E. Knipping,—*New Seismometer and Observations with same.* 18 p., 1 pl.
J. Milne,—*Earthquake in Japan of* 1880 *Feb.* 22. 116 p., 5 pl., 8 woodcuts.

Vol. II.

J. Milne,—*Recent Earthquakes of* Yedo, *Effects on Buildings, &c.* 28 p., 2 pl. and many tables.
T. C. Mendenhall,—*Gravity on Summit of* Fujiyama *(abstract).* 2 p.
H. M. Paul,—*Earth Vibrations from Railroad Trains (abstract).* 4 p.
J. A. Ewing,—*Astatic Horizontal Lever Seismograph (abstract).* 5 p., 1 pl.
J. Milne,—Peruvian *Earthquake of* 1877 *May* 9. 47 p., 2 pl., tables.
Constitution, Rules, Officers and Members of the Society, 1881 Dec.

Vol. III.

T. Gray,—*Steady Points for Earthquake Measurements.* 11 p., 3 pl.
J. Milne,—*Experiments in Observational Seismology.* 53 p., 1 pl., tables.
„ —*The great Earthquakes of Japan.* 38 p., 1 pl., many tables.
J. Perry,—*Theory of a Rocking Column.* 4 p.
E. Knipping,—*Earthquake of* 1880 *July* 25 *with* Dr. Wagener's *Seismometer.* 4 p.
J. A. Ewing,—*Earthquake Observation at three or more Stations,* &c. 4 p.
„ —*Records of three recent Earthquakes.* 6 p., 3 pl.
„ —*Earthquake of* 1881 *March* 8. 8 p., 1 pl.
J. Milne,—*Horizontal and Vertical Motion in Earthquake of* 1881 *Mar.* 8. 8 p., 3 pl.
T. Gray,—*Seismograph for Registering Vertical Motion.* 3 p., 1 pl.
J. A. Ewing,—*Seismometer for Vertical Motion.* 3 p., 1 pl,
T. Gray,—*Seismograph for Large Motions.* 2 p.
„ —*Compensating a Pendulum to make it Astatic.* 3 p.
H. S. Palmer,—*Note on Earth Vibrations.* 3 p.
M. Kuwabara,—*The Hot Springs of* Atami. 2 p.

Vol. IV.

J. Milne,—*Distribution of Seismic Activity in Japan.* 30 p., 1 pl.
T. Wada,—*Notes on* Fujiyama. 7 p.
E. Abella y Casariego,—*Earthquakes of* Nueva Vizcaya *in* 1881. 23 p., 2 maps.
J. Milne,—*Utilization of Earth's Internal Heat.* 12 p.
J. A. Ewing,—*Earthquake of* 1882 *March* 11. 5. p.
P. Doyle,—*Note on an* Indian *Earthquake.* 6 p.
J. Milne,—*Systematic Observation of Earthquakes.* 31 p., 5 pl.

SEISMOLOGICAL SOCIETY OF JAPAN.

This Society was organized 1880 March 11, at Tokio, Japan, for the purpose of investigating and studying all the phenomena connected with *earthquakes* and *volcanoes*.

For a copy of its *Constitution*, *Rules*, and *List of officers and Members*, see page 105 of this volume.

The Society has now published five volumes of *Transactions*, and an abstract of the contents of the first four is given on the preceding page. Below are given the prices for which they can be purchased by the public. *The editions of the first four volumes are nearly exhausted.*

TRANSACTIONS OF THE SEISMOLOGICAL SOCIETY OF JAPAN.

Vol. I, Parts I and II, 188 pages, 11 plates, 8 woodcuts.
Yokohama, 1881.
Price, $ 1.50. or 6 *shillings*, or 6 *marks*.

Vol. II, 103 pages, 5 plates. Yokohama, 1881.
Price, $ 0.75, or 3 *shillings*, or 3 *marks*.

Vol. III, 152 pages, 14 plates. Tokio, 1882.
Price, $ 1.50, or 6 *shillings*, or 6 *marks*.

Vol. IV. 117 pages, 8 plates. Yokohama, 1882.
Price, $ 1.25, or 5 *shillings*, or 5 *marks*.

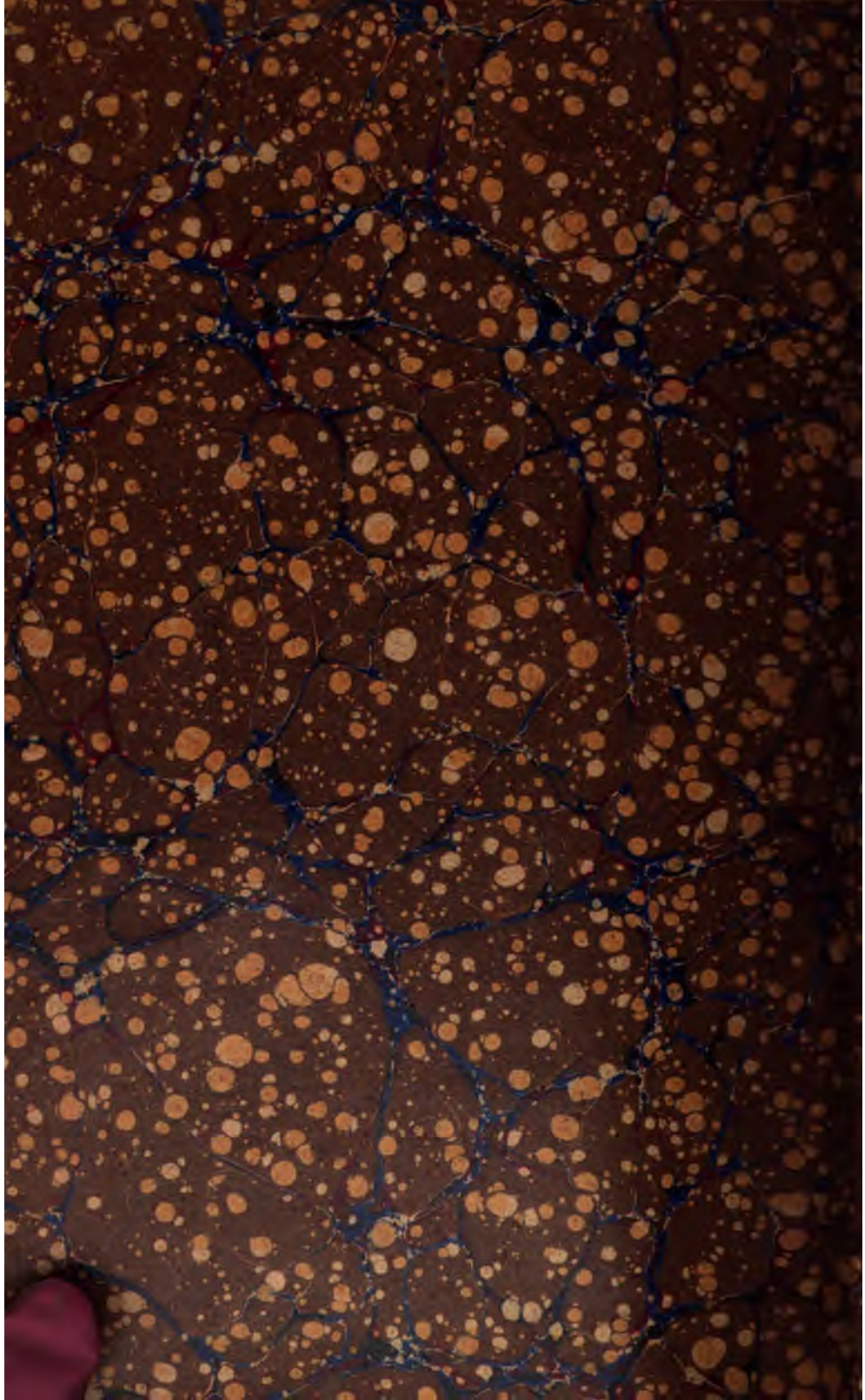
Vol. V, 112 pages, 11 plates. Tokio, 1883.
Price, $ 1.25, or 5 *shillings*, or 5 *marks*.

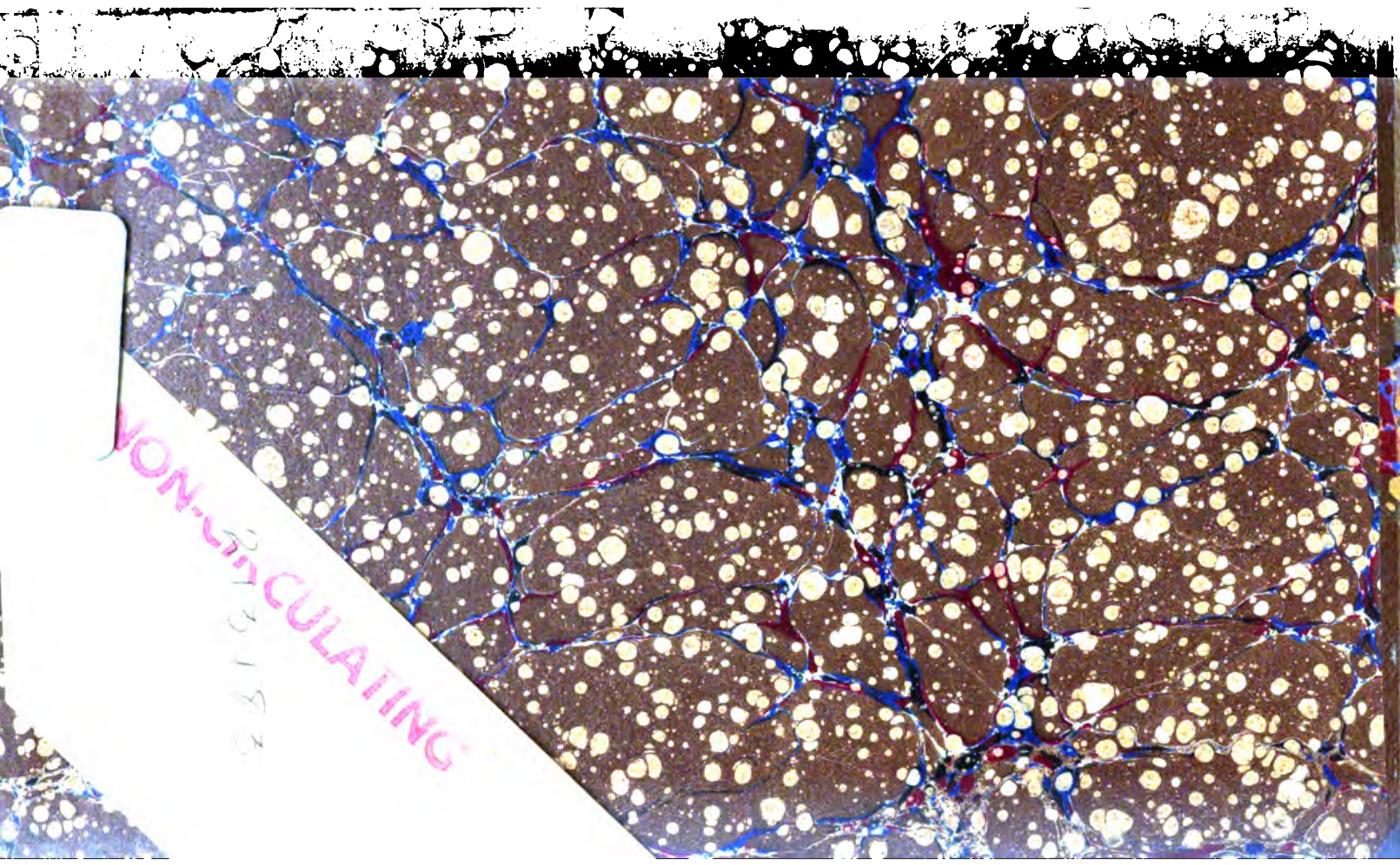
The $ prices are reckoned in the *Mexican Silver Dollar* and may be paid by *draft* on any of the Foreign Banks in YOKOHAMA.

The price in *shillings* may be paid by *P. O Money Orders* between Great Britain and Japan, payable in TOKIO.

The price in *marks* may likewise be paid by *P. O. Money Orders* payable in TOKIO, through the *Service* lately instituted between Germany and Japan through the medium of Great Britain.

All *drafts* or *P. O. Money Orders* should be made payable to the *Secretary of the Seismological Society of Japan.*




NON-CIRCULATING